

PHILOSOPHICAL TRANSACTIONS.

I. Studies on the Structure and Affinities of Cretaceous Plants.

By MARIE C. STOPES, D.Sc., Ph.D., F.L.S., Lecturer in Fossil Botany in the University of Manchester, and K. FUJII, Ph.D., Assistant Professor of Botany in the Imperial University of Tokio.

Communicated by D. H. SCOTT, Ph.D., F.R.S., Pres. L.S.

(Received May 17,—Read May 27, 1909.)

[PLATES 1-9.]

CONTENTS.

	Page
Introduction	2
Material	4
Cutting of Nodules	4
Description of Plants—	
<i>Petrosphaeria japonica</i>	4
<i>Schizæopteris mesozoica</i>	6
<i>Fasciostelopteris Tansleii</i>	10
<i>Fern rootlets</i>	15
<i>Niponophyllum cordaitiforme</i>	16
<i>Yezonia vulgaris</i>	23
<i>Yezostrobus Oliveri</i>	33
<i>Araucarioxylon Tankoense</i>	41
<i>Cedroxylon Matsumuræ</i>	42
,, <i>Yendoi</i>	44
<i>Cunninghamiostrobus yubariensis</i>	45
<i>Cryptomeriopsis antiqua</i>	52
<i>Saururopsis niponensis</i>	58
<i>Jugloxyylon Hamaoanum</i>	62
<i>Populocaulis yezoensis</i>	63
<i>Fagoxylon hokkaidense</i>	64
<i>Sabiocaulis Sakuraii</i>	66
<i>Cretovarium japonicum</i>	70
Conclusion	73
Literature	79

INTRODUCTION.

THE unique interest and importance of the palæobotanical work already done on the Palæozoic flora depends in a great measure on the nature of the fossil remains which were available for investigation. Were equally favourable material to be had from any other epoch, there is no doubt that it would be of just as great anatomical and phylogenetic interest.

It has been our inestimable good fortune to obtain petrified *débris* from the Mesozoic, so that we have been able to examine fragments of a variety of plants lying together as they drifted from the Cretaceous forests. The nodules in which these petrifactions occur are very comparable with the nodules in the Palæozoic,* as has been described in a separate paper by one of us (STOPES, 1909). They appear to be the only known structures of Mesozoic age in which such petrified plants occur.

In the present paper, the first, we hope, of a series on the subject, we are able to give a preliminary description of a Mesozoic community of plants known by their anatomical characters.

The 18 plants here described range from Fungi to Angiosperms, and though the number may not seem very great when compared with the long lists of plants often described from fossil impressions, it will appear in its true light when compared with the work on anatomical palæontology, where the investigator has usually to be content with one or two species at a time. In this connection it may not come amiss to remember that of the English Carboniferous flora, so universally known and so vitally important to phylogeny, and always described as so rich, only about 70 structural species are known at the present day, after more than 50 years' work by WILLIAMSON, BINNEY, SCOTT, OLIVER and a host of other investigators. When, therefore, after about two years' work we are able to present 18 plants from the newly discovered Cretaceous flora, we feel that there is every promise for the future of a rich harvest when other investigators have entered the new field and the necessary mass of material has been examined.

All the species here described are new, and all are described from the anatomical structure of some or other of their parts. The question of their relationship to some of the numerous fragments of leaf and stem impressions which have been described from the Cretaceous of many countries is a difficult one, a question, in fact, which at this stage it is impossible to answer. That the commonest among our petrified plants should be, in matter of fact, actually the same natural species as the commonest among the impressions is very likely, although no weight can be placed on such an assumption. The same difficulty exists in dealing with the Palæozoic floras, where the number of impressions correlated with structural material is extraordinarily small. Our nodules, however, are rather more hopeful in this respect than the

* It will be understood that these Palæozoic nodules contain numerous fragments of many parts of plants, the *débris* of a mixed flora.

Palæozoic ones, and there is reason to suppose that in the future something substantial may be done in this direction.

In dealing with the anatomy of these plants, the material has been fairly satisfactory. The preservation of the tissues is often such that all details of cell structure can be made out readily with the high power of the microscope : the finest pit canals in thickened tissue are common, and in soft tissue there are several cases of appearances which carry conviction that they are nuclei. The principal disadvantage of the material is the very small size of most of the fragments. The débris had drifted (see STOPES, 1909), not like the Palæozoic coal balls which had petrified the material where it fell, and though it had journeyed only a short distance, it shows signs of the accidents of travel. The larger pieces of wood are frequently bored, and the small twigs, leaves, etc., are often so macerated that they are not large enough to yield a series of sections. This reduces the chances of leaves remaining attached to the parent stems or fructifications to the vegetative parts. In spite of this, however, there are such twigs as *Cryptomeriopsis*, described on p. 52, where the leaves surround the parent twig.

In this present paper we do not describe all the species which have already passed through our hands, but have selected those which had some special point of interest or seemed to be particularly abundant, or well preserved, or representative of a group. There remain in the slides already in our possession a number of species to be described later, and a great number of very small fragments or parts difficult of interpretation, among which are several Angiospermic leaves in transverse section, which we hope future specimens may elucidate.

The fate of the older types of plants and the birth of the new are alike veiled in the obscurity of the Mesozoic ages. While of most of the other groups of plants some definite records have been preserved on which to base a reconstruction of their history, of the Angiosperms there are practically none. Owing to their late appearance in the world, they do not figure among the well preserved Palæozoic petrifications, as do some members of nearly all the other groups of vascular plants. Hence their early history is at present not only unwritten, but unwritable. As all recent workers who have touched on the subject have deplored, there are no true petrifications of any of their parts in the Mesozoic rocks, beyond one or two fragments of secondary wood. Hence, though far from complete, the structural details described in this paper of six Angiosperms afford a few data toward filling up an important hiatus in botanical knowledge. Scanty enough as the information must seem in the face of the numbers of plants which must have existed at the time, it is the most important contribution in this paper, though the Gymnosperm *Yezonia*, with its unique structure, is perhaps more directly interesting.

The central theme of the paper is the consideration of the plants all together, as representing the first example of a community of Mesozoic age in which the three great groups of plants seemed to be more equally mixed than in any other fossil community.

MATERIAL.

All the specimens described in this paper are from nodules found by us at different times in the Cretaceous rocks of Hokkaido, Northern Japan. The nodules usually contain numerous small fragments scattered through the matrix, though a few contain only a single stem. In nearly every case there are parts of the shells of Ammonites in the nodules. These have been described by YABE (1903), and there is no doubt, as a consequence, that the plants are of Cretaceous age. The size of the nodules is often very considerable: most of those which we cut were 4 inches to 2 feet in diameter, and some reached a much greater size. Large stems may be preserved in them, as in the case of the trunk of *Cedroxylon*, but most of the fragments are minute.

The hardness of the matrix is, as would be expected from its chemical nature (containing 30 per cent. silica, see STOPES, 1909), intermediate between that of the calcareous coal-balls and silicified wood. We found that the finer-grained nodules contained better preserved tissues than the coarse ones.

In many cases there are blackened fragments, particularly of leaves, mixed with those which consist of well-preserved tissue. These often show up as impressions when the nodules are split open.

CUTTING OF THE NODULES.

The cutting of the nodules and the preparing of the slides we did ourselves. In this work, the selecting and orientating of the blocks was very important, and, although it took much time, we found that it was time well spent, for in the course of cutting the nodules features sometimes became apparent which would have been rubbed away by the workman in the final polishing in the ordinary course of events when the work is done by a lapidary.

A fossil cutting machine was specially erected for the purpose at the Imperial University, Tokio. The details of our methods, when they are perfected, and of the new machine, will be described by one of us in a future paper.

In many of the nodules the enclosed stem or other tissues were apparent sticking through the matrix on the outside. In such cases, when it appeared worth cutting, it was possible to orientate the block on the machine, but in most cases the nodules were cut or broken open first, and the sections orientated in relation to the most promising of the specimens in it.

DESCRIPTION OF PLANTS.

Petrosphaeria Japonica.

(Plate 1, figs. 1-6.)

Fungal hyphæ are to be seen in a large number of the higher plants whose structure we consider in this paper. They appear to be of several species, and

among them are the septate hyphæ of the higher fungi as well as those of the lower forms. The fungus now about to be described was selected for the purpose because it shows at the ends of many of its hyphæ cells or groups of cells which are evidently fructifications or resting masses, and the whole is so exceptionally well preserved in comparison with most fossil fungi.

The vegetative hyphæ are numerous, penetrating the cortical tissue of the angiospermic stem described on p. 58, *Saururopsis*. Within the outer tissues of the host are also very numerous clusters of plectenchyma, or resting masses of the fungus. The tissues of the host are indeed infested with the fungus, but principally in the periderm layers. There are no signs of external fructifications.

The vegetative hyphæ are 2–4 μ in diameter, and run in the cells of the cortex in great numbers, sometimes twining and twisting so as to almost fill a cell (see fig. 1, Plate 1). Their septa do not show in many cases, but in quite a number of places septa are visible running at right angles to the hyphæ walls.

The nests of thickened cells, and end cells of hyphæ with swollen and thickened walls are also very numerous, and when mature seem to consist of a roundish or oval mass composed of a thick walled closely set plectenchyma of irregular size and shape, though commonly roundish (see figs. 4 and 5, Plate 1). The masses consist of "cells" which are large in comparison with the hyphæ, and have thick walls (see fig. 6 for such a mass in section) of a dark brown colour.

In slide 1 B 2, among others, several stages can be seen which appear to be developmental. The stage figured in fig. 2, Plate 1, shows the end of a hypha cut off by a straight septum from the swollen and thickened end cells. Fig. 3 shows a part of the mycelium swelling up in a more irregular way. Small groups of clustering, dark-coloured cells are common, and offer a good many intermediate grades between the first stages, as in fig. 2, and the large masses like those in figs. 4–6. Fig. 5 shows the compact form of a spherical body, such as is common in the cortical tissues of the host, while fig. 6 is cut in section and is suggestive of a mass which is germinating in several directions, the hyphæ *h* on the right seeming to come directly from it.

There are also in the layers of the host very numerous cells filled with a blackened frothy network, which appears not unlike cells once occupied by fungal clusters which are now effete, the fungus having probably withdrawn to the outer zones of the host.

Habit.—That the fungus was an underground form seems indicated by the fact that its host was a rhizome or the base of a stem. Whether it was a saprophyte or a parasite there seems at present no means of determining. Figures given by HARTIG (1880) show swollen, thickened cells arising from the mycelium of a living form, which are very similar to those of this fossil although less extensive. Among living forms such cells are known to function as resting stages or microsclerotia, and it is extremely probable that the fossil clusters have the same function.

The very numerous masses of resting cells combined with the ordinary vegetative hyphæ, seem to indicate that the fungus was just going into or coming out from a resting condition, which might perhaps have alternated with vegetative growth in the same or neighbouring hosts for a long time without the formation of true spore-bearing fructifications. The blackened used-up-looking cells in the cortex of the host offer some suggestion that the fungus had lived in them and had gone from them to the cells of the outer layers.

Affinities.—The septate hyphæ place the fungus undoubtedly among the higher forms, but the lack of characteristic spore-bearing fructifications makes its exact location impossible. Among members of Sphaeriaceæ, such resting masses as those in the fossil are not uncommon, and it is in this family that, temporarily at least, we incline to place the fossil.

Among fossil fungi none are known which offer any definite grounds for association with the fossil now described. The majority of fossil fungi belong either to the lower fungi, or are so extremely inconclusive that sound argument can hardly be based on them.

A miocene form described by SALMON (1903) is sufficiently similar to this new fungus for comparison, though there seems no close likeness. The groups of SALMON's *Circosporites* consisting of a very much smaller number of cells than the nests of the present fungus, and the hyphæ showing none of the irregular swollen cells which are so characteristic of *Petrosphæria*. The host, geological period, and other details differ so widely in the two cases that it is very unlikely that there is anything more than a slight superficial similarity between them.

We are much indebted to Mr. GEORGE MASSEE, of Kew, for his opinion on this fungus, which was very helpful.

Diagnosis:—

PETROSPHÆRIA, gen. nov. P. JAPONICA, sp. nov.

Hyphæ septate, 2-4 μ in diameter, the septa at right angles to the long walls. Many cells of the hyphæ irregularly swollen to a large size. These swollen cells usually thickened, and forming round or irregular nests of plectenchyma which has often extremely thick walls. These clusters, entirely within the tissue of the host, principally in the periderm.

True spore formation at present unknown.

In stem (apparently underground) of *Sauruopsis*, gen. nov.

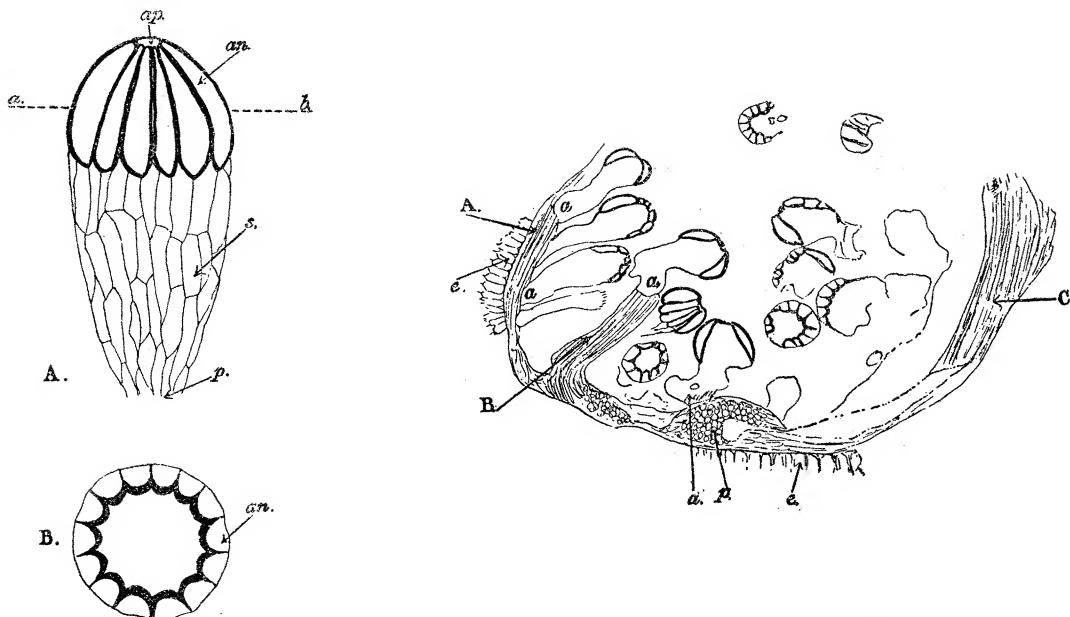
Upper Cretaceous, Hokkaido, Japan.

Schizæopteris mesozoica.

(Text-figs. 1, 2, and 3, Phot. 1, Plate 2.)

This plant we know only from a fragment of its fertile portion. This includes a number of sporangia cut in varying directions so as to give quite sufficient evidence of their structure to justify the reconstruction in text-fig. 1. The specimen is preserved

only in one section, D1 Z3, and the neighbouring slides in the series show no tissue that could be interpreted as belonging to it.

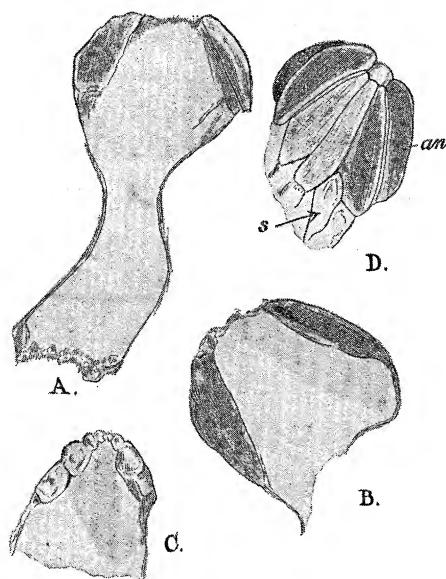


TEXT-FIG. 1.—Restoration of a single sporangium of *Schizaeopteris*.

an, annulus; *ap*, apical cell; *s*, wall of sporangium; *p*, base of sporangium. *B*, section cut through *A* at the level *a...b*; *an*, annulus.

TEXT-FIG. 2.—Outline sketch of the whole sorus as seen in Photo 1, Pl. 2.

A, *B*, and *C*, arms of sporophyll tissue possibly connected in life; *a*, attachment of some of the sporangia; *e*, epidermis cells.



TEXT-FIG. 3.—Sporangia of *Schizaeopteris mesozoica*, STOPES and FUJII.

A, longitudinal drawing of a complete sporangium, showing the base of attachment and the apical cap; *B* and *C*, details of the annulus in longitudinal and oblique sections; *D*, part of a surface view of one of the sporangia, showing the thick-walled annulus cells, *an*, and the form of the sporangial wall, *s*.

The general form of the section is seen in Phot. 1, Plate 2, where the sporangia, *sp.*, are seen attached at several places, some of which are marked *a*. The camera lucida drawing in text-fig. 2 shows the essentials of the group, and the sporangia attached to the sporophyll. The form of the latter cannot be accurately determined from the single section which is at our disposal, and which was apparently cut in oblique tangential direction to the veins, but it is very possible that the fertile portion of the sporophyll was segmented and curved somewhat to protect the sporangia which were not covered by any indusium.

The Sporangia.—The sporangia are cut in a variety of directions, a few of which are shown in detail in camera lucida drawings in text-fig. 3, A–D, as well as in the diagrams in text-figs. 1 and 2. They were 0·46 mm. long by about 0·2 mm. at the widest part of the annulus from which they gradually diminished till they were 0·06 mm. at the basal attachment. The restoration in text-fig. 1 shows the form of the complete sporangium. Except for the annulus cells the wall is generally too poorly preserved to show its detailed structure, but text-fig. 3, D shows a few cells of the surface view of the wall which indicate that the cells composing it had pointed or square ends as they fitted into each other, such as are seen in the living *Schizeaceæ*. The cells of the apical annulus are particularly large, long, and with very thickened walls, as is seen in the transverse sections, text-fig. 1, *an.* It is possible that it did not form an absolutely symmetrical cap, but there is no proof that it did not, the sections showing an apparently one-sided annulus being obliquely cut.

The absence of a stalk is a point of systematic importance, and one about which there is no doubt, as several of the sporangia are attached and cut approximately vertically; in this character, as well as in the apical cap, they are like the simpler of the Schizæas.

There are a few spores lying in and among the sporangia, but not sufficient to give any indication of the number a sporangium contained. They are considerably crushed and not very well preserved, but appear to have been triangular, and are about 0·4 mm. in diameter.

Form of the Sporophyll.—From the part we have it is evident that a large number of sporangia were massed together, and not as in *Lygodium* placed separately, each in an enclosing indusium. From indications of epidermal-like cells (seen in the drawing at *e*, text-fig. 2) it appears probable that the arms of tissue *A*, *B*, and *C* were united by laterally running soft tissue, and that they are, in fact, the veins of a foliage-like fragment. The character of the cells in *A*, *B*, and *C* supports this view, for they are considerably elongated, as are the cells over veins. No actual vascular tissue is recognisable, though there is a very narrow cell in *B* which resembles an annular thickened element, but if, as we imagine, the section is cut tangentially to the surface of the veins, it may well be that it escaped their tracheids just as it has escaped the connecting lamina. The appearance of the sporangium, apparently attached at the apex of *B*, is probably due to the sloping of the section,

or the curving of the vein, which takes the rest of the tissue out of the plane of the section. That there was something in the nature of a placental pad of tissue, possibly over the veins, seems to be indicated by the pad *p*, in Photo 1 and text-fig. 2. It is unfortunately impossible to determine whether there is vascular tissue within it because of a small break in the matrix.

It is probable that the sporangia were arranged thickly along the veins, as the row along *A* seems to indicate. If so, a tangential section cutting the veins would show a mass of sporangia such as lie in our section.

Affinities.—The form of the single sporangium, with its large apical cap and broad stalkless base, is a sufficient guarantee for the inclusion of this fossil in the family of the *Schizaeaceæ*. Among the living genera there is very considerable variety in the arrangement of the sporangia, and as there is so small a portion of the sporophyll it is impossible to say with which of them our fossil agrees most closely in general features. It is clear, however, that it does not come near *Lygodium* with its laterally seated, isolated sporangia, while in the character of the sporangia themselves it comes nearer to *Aneimia* than it does to *Schizaea*. The fossil differs from the living genera, however, in the relative massiveness of its annular cap, which appears to be the widest part of the sporangium, unlike the living genera, in which it usually narrows down to the apex. The placing of the sporangia on the veins is characteristic of the whole family; in *Lygodium* and *Mohria* there is only a single sporangium on each vein, while in *Schizaea* a double row lies along the single central vein of the reduced sporangiferous segment, and in *Aneimia* sporangia are irregularly placed on either side of the branching veins of the specialised leafy portion. It is the last genus which in a small tangential section would seem to yield the nearest approach to the fossil, though they do not agree identically, the fossil having a greater number of sporangia.

As so little vegetative tissue is present it may be well to note the only point of any possible systematic value which it seems to yield, viz., the epidermal cells seen in surface view at the tissue *A* and *B*. In the "Pflanzenfamilien," DIELS (see ENGLER and PRANTL, 1902, p. 357) notes that in *Schizaea* and several species of *Aneimia* the epidermis cell walls are straight, while in the other genera they are irregularly curved and fitted into each other. In our fossil the cells shown at *e* are seen to have quite straight walls, which supports the view of the connection with *Aneimia* based on the characters of the sporangia.

As fossil forms, there are, so far as we are aware, no other known members of this family among structural petrifications. With impression genera such as *Seftenbergia* and *Klukia*, for example, comparison is difficult and uncertain, and so far as can be judged from the published figures of these genera, our fossil agrees with neither of them.

Diagnosis :—*SCHIZÆOPTERIS*, gen. nov.

Sporangia numerous together along the veins, each standing separately on a broad base, sessile, annular cap apical, symmetrical, very massive, composed of a single row of cells. Indusium absent.

S. MESOZOICA, sp. nov.

Sporangia, 0·46 mm. long. Their annular ring the widest portion, with a diameter of 0·2 mm., consisting of 12–14 similar cells. The single cells of the annulus 0·12 mm. long. Inner walls of the annulus very much thickened. Spores 0·04 mm., triangular (?) Epidermis cells with straight walls.

Upper Cretaceous, Hokkaido, Japan.

Fasciostelopteris Tansleii.

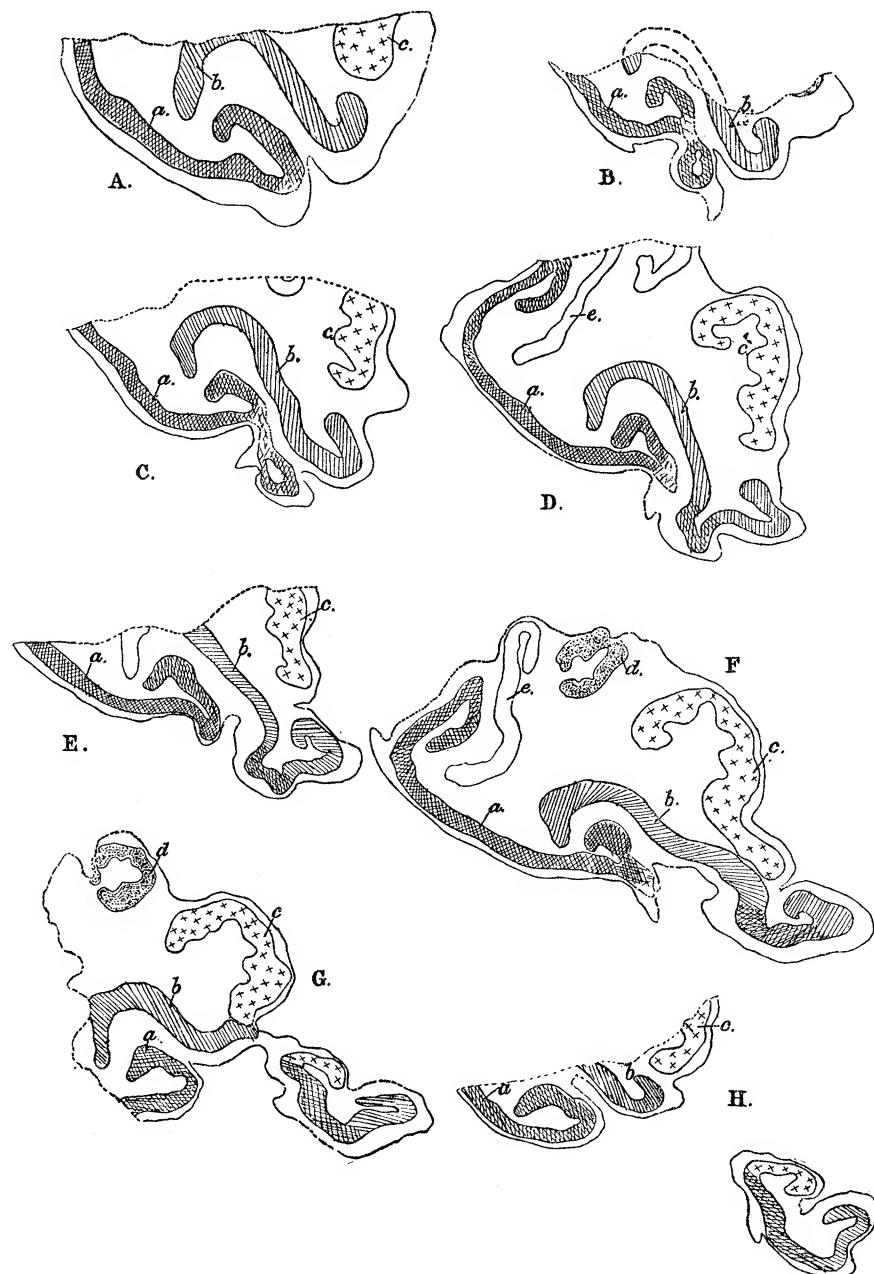
(Text-fig. 4, Photos. 2 and 3, Plate 2 ; fig. 7, Plate 1.)

Of this plant we have but one specimen, which consists of part of what we take to be the main axis of a fern with its petiole coming away from it. It is not impossible that it may prove to be a complex petiole giving off a pinna, but as there is no proof of this we will treat it as a stem. The axis is cut in transverse sections in the slides 4 K 1 to 4 K 10. Unfortunately the stem lay at the edge of the nodule partly exposed, so that the tissues on one side are very incomplete. The petiole, however, bent away from the main axis in the direction towards the middle of the nodule so that the course of its exit is determinable.

The main axis shows no clear limiting layer, but there is no reason to suppose that it was much greater than it appears in slide 4 K 6, from which we can judge its diameter to have been about 5 mm. when living. It was evidently not clothed by many closely packed leaf bases, for in the length of the part we have, *i.e.* about 1½ cm., there appears to have been but the one petiole. There is no evidence whatever of adventitious roots of any sort, and though there may have been a few of them, it is probably safe to assume that they did not clothe the stem or run in the cortex as in the Cyatheaceæ and the Palæozoic Marattiaceæ. This point is noted, because in the large curving band-like steles of its main axis this plant seems to come nearer to these families than the other groups of ferns.

The Main Axis.—The series of diagrams in the text-fig. 4 shows the extent of the stem which is preserved in the sections, and the shape and arrangement of the vascular bands. The external tissues are very poorly preserved, so that it is impossible to determine whether or not the stem was clothed with a differentiated epidermis. The main mass of the ground tissue is fairly thick walled; this is seen in Phot. 2 Plate 2, *g*. In many cases the pittings in the walls of these cells are excellently preserved, and the whole tissue is seen to be connected by the fine black lines of the

pit-canals. The cell walls are much rounded at the corners, and leave triangular spaces between them. In many of the cells there are roundish bodies lying within



TEXT-FIG. 4.—A to H, diagrams of a series of transverse sections through *Fasciostelopteris*, showing the exit of a leaf trace. Each of the steles is differently marked, and lettered *a*, *b*, *c*, *d*, and *e*. The leaf trace is seen to be composed of contributions from *a*, *b*, and *c*.

the cells, often adhering to the walls; these are somewhat suggestive of starch grains, but may perhaps be protuberances from the wall.

As a result, probably, of the generally thickened nature of the ground tissue, there

are no distinct bands of sclerenchyma, as such are so commonly found in fern stems, e.g., *Pteris* and *Cyathea*, and the zones of sclerenchyma enclosing the steles in this fern gradually merge with the ground tissue.

The Vascular Tissue.—The stem is dictyostelic, with five band-like meristoles which curve considerably and overlap, leaving an irregular central portion of the ground tissue in the middle of the stem. Their arrangement and relative positions and sizes are best seen in text-fig. 4, f which is the most nearly complete of the sections. In the diagrams the individual meristoles are differently shaded, and their changes can therefore be followed easily throughout the course of the portion of the stem at our disposal. At first they seem to be much convoluted and small as stele c in c. By following the stele c in the series of diagrams, it can be seen to spread and become more band-like as it passes up the stem. In the course of the piece of the stem we have there is no interlacing of the distinct meristoles, nor do they come into connection with each other except at the exit of the leaf trace, which is composed of contributions from three vascular bands. Whether or no the steles b and e should be considered as accessory strands and the other three only as forming the main series, is a point which is hardly determinable from the portion of the plant which is available.

An individual meristole is organised in the normal way of ferns, and is therefore concentrically arranged with central xylem. There seems sufficient evidence to suppose a complete endodermal sheath of small cells between the vascular tissues and the small thick-walled elements of the ground tissue, for the endodermis is remarkably clearly preserved round parts of the strands.

The Xylem forms a slightly interrupted single band in each of the meristoles, in some places lying in a wavy line such as is usual in the *Cyatheaceæ*, and in others forming a simple curve. The band contains one to three rows of xylem elements (see x, Phot. 2 and 3, Plate 2) which vary considerably in size, from about 0·02 mm. to 0·08 mm. in diameter. These cells seem to offer no point of distinction from the usual type of Leptosporangiate tracheids. Owing to the fact that all the sections are transverse, the nature of the pittings on the walls is not ascertainable, but the transverse appearance is suggestive of scalariform pits. Protoxylems are not absolutely determinable because the sections are all transverse, but along the xylem band are several groups of small elements at intervals, among which are in all likelihood the protoxylem elements, which thus seem to lie on the outer side of the band.

The cells between the xylem and the endodermis proved difficult of interpretation, because they are of a distinctly unusual character. They can be seen in fig. 7 in Plate 1, where the large size of the well-marked layer of cells p will be recognised at once as a rather remarkable feature. We incline to interpret this clearly defined layer of cells as a pericycle. In some Dicksonias the pericycle cells are markedly large, although not so much developed as in the present case, and they afford some sort of parallel to the layer. Some specimens of *Aneimia*, too, as Mr. Boodle has pointed out

to us, have a rather large-celled pericycle, yet in all living forms we know, the layer is far from having so distinctive an appearance as the layer *p* has in the fossil.

There seemed also some resemblance between these cells and the large sieve tubes, which equal the xylem elements in diameter, of a *Marsilia*, and more particularly between them and the sieve tubes of some of the *Marattiaceæ* in which, as SHOVE (1900) has shown, the sieve tubes are external to the protophloems. Hence for some time we thought this interpretation of the layer *p* not an impossible one. This view seemed supported by the form of the meristoles and the exit of the leaf trace, which are suggestive of a reduced *Psaronius*. This alternative view we have now discarded,* for the present at any rate.

The layer *p* in the fossil at present being described is presumably pericycle, and will be called pericycle hereafter. It is a very well-marked layer, traceable in all sections round the vascular strand *c* and partly in some of the others. The elements are noticeably large all through, and are particularly large at the curves of the stele. The cell walls appear slightly thickened in the fossil, but this may very well be due to swelling previous to petrifaction, as they do not suggest sclerised cells at all. As a rule these cells abut directly on the endodermis, but locally there are one or two small rounded cells between.

In the layers of tissue between the pericycle and the wood we must seek the phloem. This seems to be separated in most cases from the wood elements by a sheath of small cells, *w.s.*, fig. 7, Plate 1. The remaining layers of cells afford sufficient tissue to represent a well developed phloem, but to attempt the actual identification of the elements is somewhat hazardous. The thick-walled cells marked *t. ph.* in fig. 7 seem to be thick-walled (sclerised?) elements such as are not uncommon in a good many ferns; while the large cells *ph. sv.* in the same figure which occur in a few places in the fossil, are suggestive of, if not conclusively, sieve tubes. In the bays of the strands, where the wood bends in a concave form, there is a thick zone of cells between the wood and the pericycle in which there are several nests of rounded thick-walled elements like those marked *t. ph.* in the figure. They include some cells of considerable size, but as they lie between the wood and the well-marked and continuous pericycle layer they must be considered to be stelar, and are possibly sclerised phloem elements also. The endodermis is quite recognisable in a number of places, see *en.*, fig. 7, Plate 1. The cells are small, relatively to the thick-walled cells of the ground tissue next which they lie, and have thin walls.

Exit of Leaf Trace.—The leaf trace in the base of the separated petiole is a simple horse-shoe, with slightly incurved ends, see text-fig. 4, G and H.

It has a complex origin, however, and contributions run out to form it from meristoles *a*, *b*, and *c*. Owing to the poor preservation just in that region, it is not

* We are much indebted to Mr. A. G. TANSLEY and Mr. GWYNNE-VAUGHAN, who spent several hours examining this fossil, and whose opinions, generously given, have undoubtedly contributed to this conclusion.

possible to be absolutely certain of the course of the bending of *c* just at the point where it joins *b* to form the central loop of the petiolar horse-shoe, but the diagrams, dotted in the uncertain part, indicate what evidently seems to have been the course of the steles.

After the exit of the leaf trace the ends of the stem strands *c* curve in again, as is seen in the diagram H in text-fig. 4. The method of exit of the leaf trace is novel in some degree, but it can be compared in general with that of some of the simpler Dicksonias, while it is not entirely unlike the composite leaf traces of the Psaronii.

The curve of the petiole strand, instead of lying so as to face the axis, as is commonly the case in ferns, is placed at an angle of about 90° to it. This orientation of the petiole may be correlated with the habit of the plant, but from the small quantity of material at present available it is not possible to determine in what manner the plant grew. There is some suggestion of bilateral symmetry in fig. F, which might indicate a horizontal growth with consequent curving up of the petioles.

Affinities.—The curved band-like form of the stem meristoles, with the waving outline of the xylem, is like that in the *Cyatheaceæ* and a little reminiscent of the Palæozoic *Marattiaceæ*, and would suggest some affinity with one or other of these families. Among the other groups in which several meristoles occur in the stems, we are acquainted with none which have such long convoluted bands, nor the same general appearance as the fossil. The small size of the fossil stem renders the question of affinity a little more uncertain than it otherwise would be, for the stem is only 0·5 cm. in diameter, and we have therefore a suspicion that it is not mature. Considering it as it stands, and judging merely from the arrangement of the meristoles and the stelar tissues, affinity with the *Cyatheaceæ* in the old-fashioned sense seems not unlikely, particularly near the genus *Dicksonia*. Gwynne-Vaughan, 1903, describes some simple species of *Dicksonia*, including *D. Barometz*, in which the stele is broken up into a simple dictyostelic form. In this plant the leaf traces remain as simple horse-shoes for a little distance from the main axis before they break up into the numerous strands so characteristic of the family. This affords a possible parallel for our fossil in which the leaf base meristole is a single one. The majority of forms in this family, as is well known, have numerous meristoles in the stem and a very large number of small strands in the petiole, but our fossil seems to be organised on the lines of a slightly more complex *Dicksonia Barometz*. Our specimen was broken off at the point where the petiolar strand became free from the main axis, so that it is impossible to know whether or not it broke up into a number of small strands as in the living species, or whether it remained in its simple curved form throughout.

The general appearance of the meristoles is very similar to that of *Caulopteris Brownii* (*Cyatheaceæ*) figured by CORDA : in which there are also five steles as in our fossil, but in CORDA's specimen the numerous roots in the ground tissue, which even

lie internally to the steles, make a point of difference which may be correlated with its greater size, or may be of some systematic importance.

The uniformly thick-walled ground tissue, in which no secretory cells are to be seen, does not favour the view of Marattiaceous affinity, which is indeed only suggested by the *Psaronius*-like form of the vascular strands. It is of course not at all impossible that in the past some members of the *Schizaeaceæ* or *Gleicheniaceæ* may have had such a structure as this fossil, though there is nothing to support an incursion into such theoretical fields.

In the manner of its leaf trace exit, and the histology of its pericycle and phloem, it appears to be unique. It certainly seems to approach nearer to some of the Dicksonias than to the other living ferns known to us, and may therefore for the present be provisionally included in the Dicksoniaceæ.

Diagnosis :—

FASCIOSTELOPTERIS, gen. nov.

Stem dictyostelic, with five meristoles, each a long curved band. Petiole with simple horse-shoe shaped meristole at the base, originating from three stem meristoles. Petiole placed at an angle of about 90° to the axis. Pericycle cells very large, equalling the metaxylem in diameter.

F. TANSLEII, sp. nov.

Stem 5 mm. in diameter. Stelar tissue occupying much of its space. Ground tissue with a zone of small thick-walled cells surrounding each strand of stelar tissue. Petioles far apart. Petiole 1.5 mm. in diameter, the arms of its meristole slightly in-curved.

Upper Cretaceous, Hokkaido, Japan.

Fern Rootlets.

(Phot. 4, Plate 2.)

In a number of the blocks are small fern rootlets, cut in transverse and oblique sections. These are unattached and may very well belong to either or all of the ferns in the nodules. They have the simple diarch type of stele, universal among modern Leptosporangiate ferns, which was already current in the Palæozoic epoch among the Botryopterideæ.

The slides 5 A 15 to 5 A 21 and 4 Q 22 to 4 Q 30A contain the best sections, from which the following short description is taken. Phot. 4, Plate 2, shows one of the best preserved transverse sections, which was about 0.9 mm. in diameter.

The cortical region is divided into two very distinct zones: an outer one of large cells, which are roundish or hexagonal, with relatively thin walls, and an inner zone of very thick-walled small cells three or four rows deep. The latter are often very

much blackened as well as thick walled, and their preservation is usually somewhat imperfect.

The endodermis is broken, but some of the radial walls are left sticking to the thick-walled inner cortex. The soft tissues have contracted somewhat away from the latter, but are present, though rather crushed, and represent the phloem and other soft tissue on either side of the wood. The protoxylems are well preserved, in two groups at opposite ends of the diameter of the stele. They consist of three to six small elements, while the metaxylem consists of two large tracheids in the centre, and one or two smaller ones at either end acting as a transition to the protoxylems. The wood elements are scalariform, as is seen in oblique sections, and in the large tracheids have two or three rows of short pits in the surface view.

Niponophyllum cordaitiforme.

(Text-figs. 5, 6, and 7, Phot. 14, 15, and 16, Plate 3.)

Of this species we have two specimens, which occur with a number of other plant fragments in blocks from Yubari. The leaf is seen in transverse series in sections 4 J 5 to 4 J 19; and though slightly broken in some of them owing to cracks in the matrix, it is perfect in a number of the sections.

The leaf (or pinnule as it very likely may be), is broad with very slightly incurved edges, see text-fig. 5, and Phot. 14, Plate 3. In the course of the sections it increases in breadth from 6 mm. to 9 mm., and its thickness is about 0·4 mm. In the first section there are 21 vascular bundles situated about equi-distantly along its course, and in the broader sections there are 33. But although in a few cases two of the bundles come slightly closer to each other than do the rest, there is no bundle in the process of dividing in any of the sections. Allowing for the loss in cutting and grinding, the fragment of the leaf must have been about 2·5 cm. long. Judging from these data, and noting where possible which pair of bundles seem to lie closest together, and therefore to have been the last to have branched, the diagram in text-fig. 6 was constructed to show the characters of the venation.

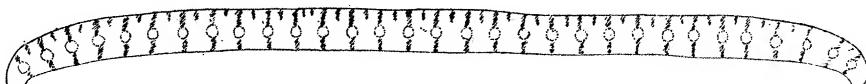
The complete absence of resin ducts makes it improbable that this leaf belonged to any of the Coniferæ, as also does its vascular anatomy. We had therefore to compare it with the lower Gymnosperms, but in the extremely close placing of the veins it seems to differ from any living species.

Had this plant occurred in Carboniferous material, its exarch vascular strands, specialised bundle sheath, and well developed sclerenchyma supporting and alternating with the bundles, would have sufficed to place it with *Cordaites* without any question. But the specimen is from the Upper Cretaceous, so that the problem is not easily solved.

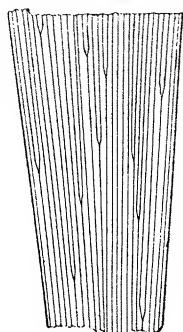
Detailed Description of the Tissues.—The leaf, as can be seen in Phot. 14, Plate 3, and text-fig. 7, has a well differentiated upper and lower surface,

The *Upper Epidermis* consists of slightly flattened cells with small lumina, and thick outer walls. In several of the sections there is a continuous line just beyond the outer thickening, which suggests a separable cuticle, which may have been detached during fossilisation. The epidermis layer is continuous, unbroken by stomates, glands, or hairs.

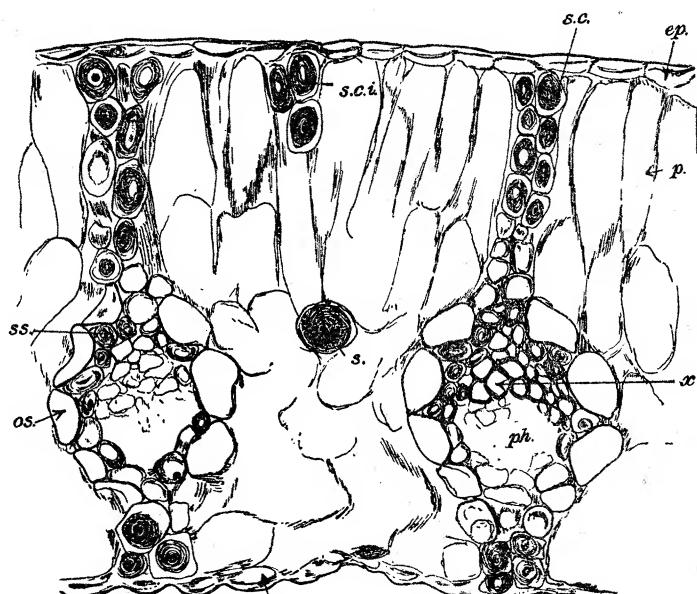
The *Palisade Cells* are large, oblong cells, stretching across the leaf from one-



TEXT-FIG. 5.—Transverse Section of the Leaf, *Niponophyllum*, showing the number and position of the vascular bundles in a typical section, and also the supra- and interfascicular strands of sclerenchyma (shown by shading). $\times 14$.



TEXT-FIG. 6.



TEXT-FIG. 7.

TEXT-FIG. 6.—Portion of the Surface of *Niponophyllum* Leaf, constructed from the data found in a series of sections, to show the venation. $\times 2.5$.

TEXT-FIG. 7.—*Niponophyllum cordaitiforme*, STOPES and FUJII. Transverse section of a portion of a leaf showing two of the numerous parallel vascular bundles. (cf. text-fig. 5).

ep., upper epidermis; *p.*, palisade cells; *sc.*, sclerenchyma bands above and below each vascular bundle; *sci.*, interfascicular sclerenchyma strands; *s.*, isolated stone cells; *os.*, outer bundle sheath; *ss.*, inner, sclerised, bundle sheath; *x.*, xylem; *ph.*, space, sometimes still occupied by phloem; *e.*, lower epidermis. $\times 180$.

third to nearly one-half of its thickness (see Phot. 14, Plate 3, and text-fig. 7). They come immediately under the epidermis between the sclerised patches, which are so placed that in most cases two or three palisade cells lie together, between the intervascular sclerised patches and the supravascular sclerenchyma.

The rest of the mesophyll is not very well preserved, but where the cells are

present they are roundish, and packed together with very few air spaces, and with no cells among them which can be recognised as transfusion tissue, nor are the cells elongated laterally between the bundles as they are in Cycads.

The *Sclerenchyma* is principally developed in supporting bands above and below the vascular bundles, as previously mentioned, and in small groups between the bundles (*sc.*, see text-fig. 7), but at the edges of the leaf there is a continuous layer of sclerised hypoderm, and the actual edge consists of a small group of sclerenchyma.

The cells are small, 0·02–0·03 mm., roundish in shape, and with much thickened walls which in most cases have contracted away from the middle lamella in the process of fossilisation (see text-fig. 7), so that there is a wide zone between the thickening and the original wall.

As well as these regularly disposed sclerised cells there are a few round isolated ones, with extremely thick walls, which are found scattered among the mesophyll (see *s.*, text-fig. 7). These are reminiscent of the scattered round cells, with much swollen walls, which are found in the leaves of some Cycads, and which contain a little tannin in their small lumina.

The *Vascular Bundles* are each enclosed in a double sheath of specialised cells. The outer cells of the sheath are clear, large, oval cells, 0·05 mm. in diameter, which appear to have been thin walled, and with little contents. They join on to the sclerenchyma above and below the bundle, and there are usually from three to five such cells on either side of the bundle (see *os.*, text-fig. 7). Within them there is a sheath of smaller slightly irregular sclerised cells, varying locally from one to two layers. Their walls appear distinctly sclerised (see *ss.*, fig. 7, and Phot. 16, Plate 3), but the cells are not so large or so thick walled as those of the extrafascicular sclerenchyma groups.

The *Xylem* consists of but few cells, grouped irregularly, and not in the radially arranged rows common in the higher Gymnosperms. This is seen in Phot. 15 and 16, Plate 3, and text-fig. 7, *x.*, and in several cases among the series of sections the protoxylems can be clearly recognised projecting into the space usually left by the decayed phloem. Sometimes only a single cell, slightly isolated from the others, projects in this position; in other cases a group of two or three (see *px.*, Phot. 15, Plate 3). Hence the bundle appears to be exarch and the wood entirely centripetal. But the number of elements is small, and as there are no longitudinal sections it is difficult to determine absolutely whether or not one or two of the small tracheids might not be centrifugal. In most of the cases where the protoxylem is recognisable, however, there are only two, or even only one element, so that the presumption is that the wood is all centripetal.

As we have not been able to recognise any true centrifugal xylem in any of the bundles, it seems as if this fossil leaf differs from the living Cycads, and, according to WIELAND's description, also from the leaves of *Cycadeoidea*, where there seems to be a considerable quantity of centrifugal xylem.

The *Phloem* is in the majority of cases only represented by a space where the tissue has been destroyed, but in a few of the strands, particularly the smaller ones near the edge of the leaf, the cells are all preserved. They are not sharply differentiated, like those of modern Cycads, and seem to have been rather irregularly shaped thin-walled soft tissue with no very salient character.

Secondary Tissues or Cambium are not apparent in any section.

Resin Ducts, Secretory Parenchyma, and Transfusion Tissue are also apparently absent, as we could not recognise any of them in the material which is sufficiently well preserved to lead one to expect to be able to see them had they been there.

The *Lower Epidermis* is not so regular and thick walled as the upper, and is poorly preserved, though in some sections its outer walls appear to be thickened and produced into low papillæ. Stomates are not at all well preserved, though it is evident in some sections where they were situated. The character of the guard cells cannot be recognised.

Affinities.—The only groups of higher Gymnosperms with which this broad leaf offers any comparison are those of the *Araucariaceæ* and *Podocarpeæ*. The absence of resin ducts, and the irregularly grouped arrangement of the wood, which is practically all, if not all centripetal, are, however, differences of sufficient systematic importance to separate it decidedly from these plants whose leaves always have resin ducts, and whose centrifugal wood and phloem are arranged in radial rows.

Among living plants, therefore, there are none with which to compare it but the Cycads, though the fossil differs from them also.

The lack of secretory canals separates the fossil from the living genera *Dioon*, *Encephalartos*, and *Stangeria*, while the midrib of the living *Cycas* removes it from comparison with the fossil. With all the other five genera there is a certain amount of likeness. The absence from the fossil of the elongated cells of transfusion tissue, which lie between the bundles of living Cycads, and the practical or entire absence of centrifugal wood, are points of distinct importance.

We are aware how the different species of the same genus of Cycads vary in detail, and though we have examined representatives of all the genera, we have not been able to obtain material of more than one or two species of each, so cannot feel certain that some one or other of the living forms may not come closer to the fossil than those we have seen.

So far as we can judge, *Microcycas* seems to come nearer to it in internal structure than the other genera, both in its outer bundle sheath, the groups of sclerenchyma between the bundles, and the well developed palisade. The possibility of connection between this Cretaceous form and *Microcycas* is of interest when we remember the discovery by CALDWELL (1906) of the numerous sperms in the pollen tube, and other features which indicate that *Microcycas* is the most primitive genus of Cycads in one direction.

Niponophyllum differs from the living Cycads in other points, as well as the absence

of transfusion tissue and centrifugal wood. The bundle-sheath is much more distinct and better differentiated in the fossil than in the living forms; the veins of the fossil, too, are very numerous, and lie very close together. In most Cycads there are far fewer veins, even in broader leaves, and they are placed at greater distances from each other, while in the narrow leaves comparable to the fossil, there are half a dozen or a dozen veins in the same width in which the fossil has twenty or thirty. In the fossil the veins are about 0·3 mm. apart, in living Cycads they average 0·6 to 1 mm., and sometimes considerably more. WIELAND (1906) does not mention this point in describing the leaves of *Cycadeoidea*, but from his photographs of the leaf structure (see p. 83) we can estimate them to be 0·14 mm. or even less apart. As regards *Cordaites*, STOPES (1903) states that the veins of *C. principalis* are 0·45 mm. apart.

Among impressions of fossil Cycadean leaves, we have found none corresponding exactly to the fossil. In all cases in the specimens and figures we have examined the veining is much coarser and resembles more that of living Cycads. It is, of course, very possible that in impressions the very delicate veining might not have been preserved.

Although none among foliage impressions entirely coincides with this fossil, *Podozamites* seems to come nearer to it than do the rest. As seen in our small fragment (text-fig. 6), the veins remain almost parallel to the edge of the leaf and to each other, much as they do in *Podozamites*, thus differing from *Zamites*, in which the coarser veins begin to go out to the edge quite near the base of the leaf, and run parallel only in the middle portion. *Otozamites*, *Dictyozamites*, and others, with their various types of venation, are quite out of consideration in comparison with *Niponophyllum*. We assume, while comparing with *Podozamites*, that our leaf is a pinnule of a compound leaf, which is a very reasonable supposition. It is equally possible, however, that it may be a simple leaf, which was attached to the branch directly, as was the case in *Cordaites*.

The most natural assumption is that it is the pinnule of a compound "Cycad" leaf. In which case it is with *Cycadeoidea*, as described by WIELAND, that we find a closer agreement in structure than with other Cycadean types. The upper figure in WIELAND's (1906, fig. 45, p. 83) photograph of the tissues of *Cycadeoidea ingens* leaf shows an outer sheath joining on to the supravascular bands of sclerenchyma which much resembles that in our fossil. But in his diagram 4, on p. 88, the character of the sheath cells is not brought out, nor does he state in his description whether or not the inner sheath cells (which he describes as small celled on p. 92) have thickened walls. This point we noted in our fossil (see text-fig. 7, ss.), because in this feature it is more precisely differentiated than in the Cycads where the sheath is irregular, and it agrees almost exactly with *Cordaites* (see STOPES (1903), fig. 5, ss.). Unfortunately, we have neither oblique nor longitudinal sections of *Niponophyllum*, so that there is no indication whatever of the nature of the pitting of these walls, and we

cannot tell whether or not they are provided with bordered pits as they are in *Cordaites*.

To return to the comparison with *Cycadeoidea*, WIELAND describes the wood of the bundle as (p. 92) "of mesarch, collateral structure, without radial arrangement of either xylem or phloem," and in his diagram 4, p. 88, shows an undifferentiated mass of about 25 wood cells, in the centre of which he says the protoxylem lies. In this respect, then, the fossil *Niponophyllum* differs from the Cycadeoidean as well as from the modern Cycadean type, for the number of wood elements is very small, generally less than a dozen, and there is little or no centrifugal wood. This is the case in the majority of species of *Cordaites*, while in modern Cycads the centrifugal wood tends to die out in the finer branches.

The presence of interfascicular sclerenchyma is noted by FRITSCH (1903), as being a character which is sometimes of generic value. It is worth comparing this point, therefore, in the genera nearest to the new fossil. In *Cycadeoidea*, according to WIELAND's photos (p. 83), and to his description, "a layer of hypodermal sclerenchyma, several cells thick, opposite to the bundles, but diminishing to a single cell in thickness between them" (p. 92), represents the sclerenchymatous system of the leaf. This is similar to the case in many of the living Cycads. In *Niponophyllum* there is no regular hypoderm, except at the edges of the leaf, and the sclerenchyma comes above and below the bundles, and also in definite interfascicular groups (see text-fig. 7). Such an arrangement is also found in *Cordaites*, where it is a characteristic feature of several of the species. Among living Cycads there is a weakly developed condition of the same thing in *Microcycas*, which has already been noted as showing a certain similarity to *Niponophyllum*.

Generally speaking, in those cases which we have observed it appears as though the Cycadean foliage has either a continuous band of sclerised hypoderm, or, as in the case of *Bowenia*, only a sclerised epidermis, or else no hypoderm, and interfascicular groups of sclerenchyma. *Cycadeoidea* and the majority of Cycads belong to the first type, and *Niponophyllum*, *Cordaites*, and some of the Cycads, to the second.

The consideration of the apparent absence of transfusion tissue in the leaf of *Niponophyllum* led to some observations which seem to have a bearing on the whole question of transfusion tissue in Cycads. WIELAND mentions, in describing *Cycadeoidea*, rather doubtful cells of possible transfusion tissue which extend from the lower side of the bundle. These cells are not differentiated in the photos or diagram of the leaf, and were we to judge from the photos alone we should feel justified in stating that the elongated, horizontally extended cells running between the bundles in so characteristic a fashion in modern Cycads (see WORSDELL, 1897) are not present in *Cycadeoidea*. One of us (M. C. S.) was privileged to see Dr. WIELAND's specimens at Yale University, and could not detect any undeniable transfusion cells in the actual slides. In this respect *Zamiophyllum* resembles *Cycadeoidea*, and both differ from modern Cycads and from *Cordaites*.

The venation in all the genera, however, is simply parallel, with no cross connecting branches, so that one would expect transfusion tissue to be present in all of them, for, as WORSDELL (1897, p. 304) says: "In all these plants (speaking of Gymnosperms and specially of Cycads) there is an entire absence of the complex, reticulate system of conducting tissue, such as is met with in Dicotyledonous plants* In order to compensate, therefore, for the lack of an efficient conducting system in the leaf, recourse has been had to the development of these peculiar tracheids now known as 'transfusion tissue' In the pinnæ of all other (other than *Cycas* and *Stangeria* with their special venation) Cycads, and in *Podocarpus Nageia*, R. Br., *Dammara*, and *Araucaria*, among Conifers, a system of parallel venation prevails, and here transfusion tissue is markedly developed."

Hence we considered the absence of transfusion tissue in *Zamiophyllum* and *Cycadeoidea* as a point worth noting, and for the sake of comparison we measured a number of the elongated transfusion cells of several genera of living Cycads, as well as the spaces between their bundles. Between the very closely placed veins of *Cycadeoidea* we found that there is not room for a single one, and in *Niponophyllum* not quite room for two of the elongated cells such as lie between the widely spaced Cycadean veins. We note, however, that there are not wanting living Cycads which have widely spaced veins, and which, notwithstanding, lack specially elongated transfusion cells, as in some species of *Dioon* and *Bowenia*, though it appears to be generally assumed that all Cycads have transfusion tissue. We examined the case of *Bowenia* carefully, and noted that the whole leaf is little differentiated and appears to consist of rather thin-walled cells. The lack of specialised transfusion tissue in *Bowenia* may be correlated with the undifferentiated character of the whole leaf, which, consisting almost entirely of soft parenchyma, would facilitate the transmission of water in any direction. *Microcycas*, on the other hand, which is quite xerophytic in its organisation, though having an actual space between its veins only one-third of that between the veins of *Bowenia*, yet has the longest and most differentiated transfusion cells of any we measured. It is possible, therefore, that the absence of transfusion tissue in the fossils may be considered a specific character, as in the case of *Bowenia*; but as they are so much more like the xerophytic *Microcycas* in their organisation, it seems very probable that it depended on the closeness of the veins, which made the system of conducting tissue more efficient. It remains a fact that the closeness of the veins in *Cycadeoidea* and *Niponophyllum* (to a less extent), makes it a physical impossibility for such elongated cells as the true Cycadean transfusion tissue to be present between the bundles, while the closeness of the veins may remove the physiological necessity for them.

In conclusion, *Zamiophyllum* seems to lie somewhere between *Cordaites* and

* The veining of Monocotyledons is more comparable, as it is parallel, and in them there is a fine cross network of veins between the main ones, which makes the conducting system efficient. Note by M. C. S. and K. F.

Cycadeoidea in its anatomy, with a closer similarity to the former than to the latter if we compare the whole *Cordaites* leaf with our blade. If it proves that *Zamiophyllum* has compound leaves its external morphology will be, with its parallel dichotomising veins, entirely Cycadean.

That leaves which remind one so much of *Cordaites* should have persisted to the Upper Cretaceous is a point of considerable interest. M. ZEILLER (1907) has recognised the possibility that some of the impressions known as *Yuccites*, and others in the Lower Mesozoic, may have really belonged to the Cordaitæ, but no anatomy has been described for such forms. Was the plant to which our leaf belonged a primitive type of Cycad, or perchance a belated, small-leaved *Cordaites* surviving in this island of the Orient, just as the truly archaic *Ginkgo* survived to the present geological epoch?

Diagnosis:—

NIPONOPHYLLUM, gen. nov.

Veins of the leaf parallel, very fine and numerous, little branched. Resin ducts absent. Wood in the vascular bundles nearly all centripetal, the cells irregularly grouped. Bundle sheath very well differentiated, and of a double nature. No elongated transfusion tissue between the bundles.

N. CORDAITIFORME, sp. nov.

Leaf about 9 mm. in the widest part. Veins 21 to 33 in number, about 0·3 mm. apart. The veins of the leaf slightly inrolled. Sclerenchyma wedges above and below the bundle, and also between the bundles on the upper side. Palisade layer well developed. Stomates only on the lower side.

Upper Cretaceous, Hokkaido, Japan.

Yezonia vulgaris.

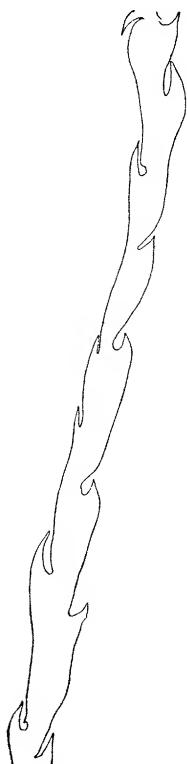
(Text-figs. 8, 9, 10, and 11; Photos. 5, 6, 7, 8, Plate 2, and 9, Plate 3, and 19, Plate 4.)

This plant appears to have had the most numerous representatives in the flora we are describing, judging from its relative frequency in the nodules. We have stems of three sizes, leafy twigs with their leaves attached, in both longitudinal and transverse sections, and innumerable scraps of leaves and stems in many nodules. The most important series of sections is one through a stem with secondary wood, and with its leaf bases attached. This is cut in slides, 6 H 1 to 6 H 10, which contain practically nothing but this stem. In the large nodule, 1 B, are numerous other plants, as well as three stems of *Yezonia*, which are cut in transverse or oblique section, as well as several leafy twigs in all the sections from the block. In the large nodule, 4 Q, in which there are innumerable fragments of other plants, there is a noticeable longitudinal section through a leafy twig of *Yezonia* in slide 4 Q 22. A

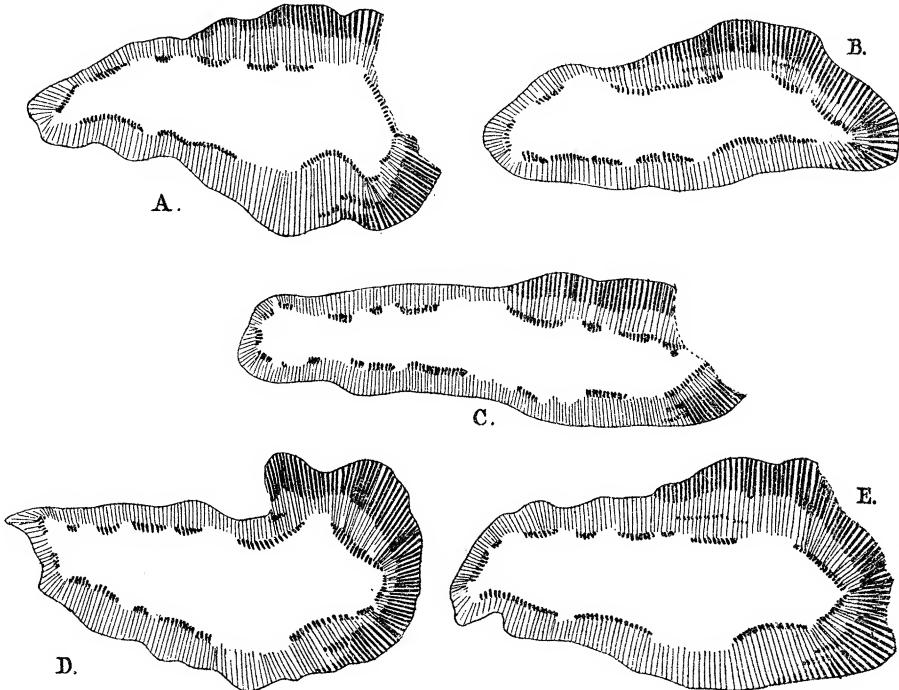
large proportion of all the slides from this material also contain some portions of this plant.

The plant is a Gymnosperm with small adpressed leaves, which in external appearance must have been not unlike those of a present-day member of the Cupressineæ, but the young leafy twigs were unbranched for a greater length than is common in the present types.

Detailed Description of the Fossil: the Axis.—In its primary condition the axis,



TEXT-FIG. 8.



TEXT-FIG. 9.

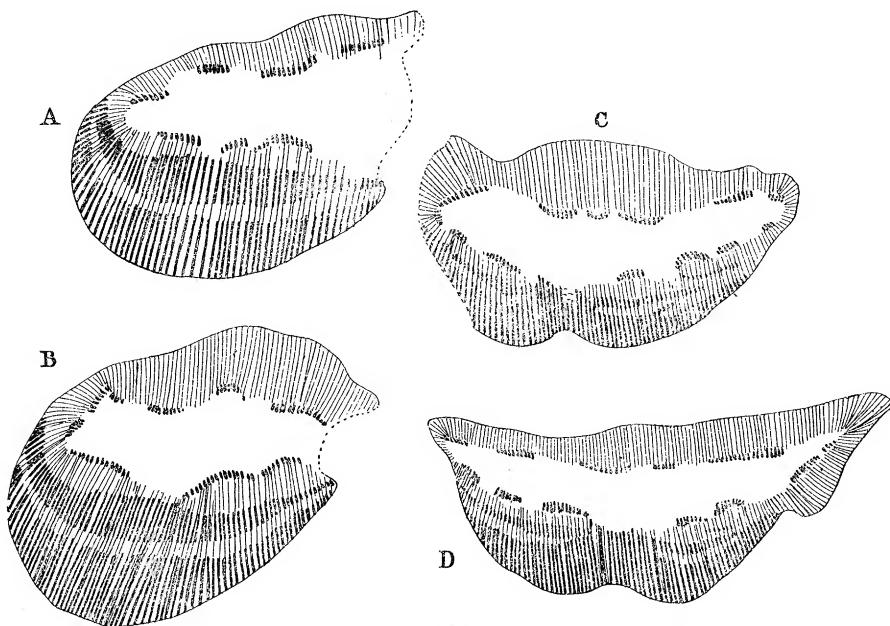
TEXT-FIG. 8.—Part of a Longitudinal Section through a long Foliage Twig of *Yezonia*, to show the form of the small adpressed leaves. (Drawn in outline from a section.)

TEXT-FIG. 9.—Diagrams through the Stem of *Yezonia*. These were drawn from a series of sections, with the camera lucida. The thick lines indicate the position and extent of the "thick-walled" wood, and the finer lines that of the "thin-walled" wood. The thick short lines abutting on the pith indicate the primary wood, which is thick walled.

or perhaps we should say the small leaf-bearing axis, has a ring of separate vascular bundles round a wide pith, with a considerable zone of cortex. Allowing for crushing of the plant previous to fossilisation, there seems to be no doubt that this axis was somewhat flattened. In the older stems the flattening seems to continue, and the primary bundles remain distinct, but outside them a zone of normal secondary tissues forms a complete, somewhat flattened cylinder. These secondary tissues consist of what appear to be thin-walled elements, with zones of thick-walled

elements of the same diameter, and lying on the same radius with perfect regularity, but the patches of thick-walled elements seem to lie among the thin-walled wood, according to no visible plan. As can be seen in the text-diagrams, there is a tendency for the former to lie rather on one side of the axis, but this is not at all universal, as is seen by a comparison of text-fig. 9, d. The principal stems are shown in diagrams in text-figs. 9 and 10, which illustrate the general aspect of the woody cylinder of this plant, as it changes from section to section in a series.

Outside the wood the cortex and leaf bases are hardly to be separated from each other, and even in the largest stem we have the leaf bases seem to have been persistent, and to have remained physiologically active, as their stomates and other tissues are still present. The size of the largest stem, which is a little incomplete



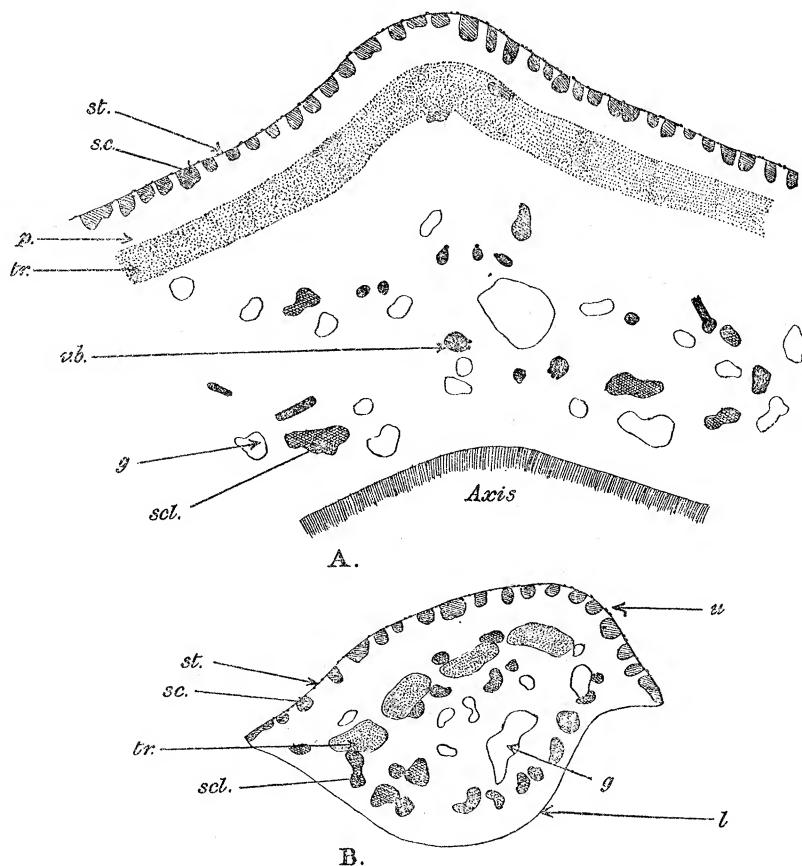
TEXT-FIG. 10.—Diagrams through another stem of *Yezonia* constructed as in text-fig. 9.

and somewhat oblique, seems to have been about 1 cm. by 6 mm. Very near to it is a smaller stem, which may have branched from it, but there is no evidence of this in the sections. In fact, though so many specimens are in our hands, we have none which shows evidence of branching, though in one case there is a longitudinal section of a twig nearly 3 cm. long, and it should certainly have shown it, therefore, had branching been at all frequent. In one slide there is a half-circle of bundles, in what might be a leaf base, or might be a branch. These bundles, however, are not to be seen in either of the neighbouring slides of the series, so that if they had been those of a branch, it must have left the main axis at a very high angle.

Young Stem.—There is only one section of an unthickened axis, that in slide 1 G 9.

In the unthickened axis the only point to be noticed is the vascular tissue, the rest of its structure seems to be identical with that of the older stems.

Round the pith, in which lie numerous groups of sclerenchymatous cells, is a ring of bundles, each separated widely from the other in most cases. There are 16 or 17 bundles, though it is impossible to be sure of the exact number, as one or two of them seem to run together. An average bundle consists of about 25 wood elements of small size, with one or two protoxylem elements at the innermost side of the bundle, and the metaxylem forming slightly irregular radial rows. Behind this a blackened structureless patch, which was evidently the phloem. There is no sign



TEXT-FIG. 11.

- Diagram of leaf base of *Yezonia*, attached to the axis. *scl.*, sclerised nests in ground tissue; *g.*, secretory passages; *v.b.*, vascular bundles; *tr.*, zone of transfusion tissue; *p.*, palisade layers; *sc.*, strands of hypodermic sclerenchyma; *st.*, stomates, alternating with the latter.
- Diagram of free part of leaf of *Yezonia*, lettering as in A.

of cambium. In this stem there is no indication of the irregularity which comes with the secondary wood.

The leafy twigs cut in longitudinal section are often very long and slender; for instance, one twig 3 cm. long is only 1 mm. to 2 mm. in diameter, including the leaf bases.

Stem with Secondary Wood.—The *Pith* is somewhat oval in outline, in most sections a little crushed, but not materially so in those shown in text-figs. Its

oval shape was natural and not due to crushing. The individual cells are large, 0·06 mm. in diameter, roundish, somewhat irregular, fitting together so as to leave but few air spaces between them (see Phot. 5, Plate 2). In the midst of these parenchymatous cells are several irregular groups of thickly sclerised elements (see Phot. 5, Plate 2). In transverse section they are round, or very irregular in outline, and so thickened as to have very small lumina; in longitudinal sections the cells are more irregular, with somewhat pointed ends.

The *Protoxylems* are endarch, and lie at the points of the bays of primary wood (see *px.*, Photos. 5 and 6, Plate 2). In oblique section they can be recognised by their spiral and annular thickenings.

The *Primary Wood* does not form such definite bundles as were noted in the young stem, but lies somewhat irregularly distributed all round the pith (see *w.*, Phot. 6, Plate 2). We have no longitudinal section which shows the type of markings on the wall, but judging from the leaf traces, the primary wood has scalariform thickenings or very small pits.

The *Secondary Wood* forms a complete, flattened cylinder. It is very uneven in its thickness, in one place consisting of about 30 radial rows of cells, and at opposite sides of the same stem of about 10. Furthermore, the elements, although of the same shape and size, differ considerably in the thickness of their walls, some being very thick walled, and others quite thin. This can be seen in Photos. 5, 6, and 7, Plate 2, where *kw.* is the thick-walled wood and *tw.* the thin-walled. This irregularity does not appear to depend on petrifaction, as the tissues are all well preserved in the plant, although it is not impossible that, owing to some difference in the chemical composition of the walls, the apparent thinness may be due to some change previous to petrifaction. In many sections the thin-walled elements are somewhat crushed owing to their delicacy, but in some cases, as is shown in Phot. 7, the thin elements are not disturbed, and follow in normal radial rows directly after thick-walled elements. This is seen in Phot. 7, Plate 2, under the high power, and illustrates at the same time the similarity in size and shape between the two kinds of cells, and the difference in the thickness of their walls. Round bordered pits can be seen in one or two cases in oblique sections on the walls, both of the thick- and of the thin-walled elements. They are placed in a single row, and are not close together. Judging from the difficulty we had in finding any pits in the wood, they were not very numerous.

The relative disposal of the thick- and the thin-walled elements in this secondary tissue is a peculiar feature of the stem. It is illustrated in the series of diagrams A to E, text-figs. 9 and 10, where the outlines are drawn by camera lucida. In some places in these figures the thin-walled tissue appears a little narrower than it probably was during life, as it is somewhat crushed, but even allowing for this, a very considerable irregularity remains. In this series of diagrams it will be noticed how the main bays of thick-walled tissue are not found in any constant position, but

that, judging from the series of consecutive sections, A to E, fig. 9, and the second series, A to D, fig. 10, tends to be on one side or the other of the stem axis. The minor irregular patches of thick-walled elements seem to be quite inconstant. The condition seen in text-fig. 10, B, is frequently found, and in block 1 B there are several sections where the double curve of thick secondary wood alone is preserved, and can be recognised lying in the matrix without any other tissue of the plant.

There is no sign of annual rings of the usual type nor of wood parenchyma, the secondary wood being like that of a *Cryptomeria*, for example, one solid mass of tracheids.

The *Medullary Rays* are not numerous or large, and consist of single rows of small cells. These are seen in oblique section to be but one cell high in general, a few only being two cells in height. We could see no clear case of pitting in their radial walls.

The *Cambium and Phloem*, which presumably lie in the crushed region just outside the wood, are too poorly preserved to call for description. Sclerised cells are apparently absent from the phloem, for it is likely that they would have been preserved had they been present.

The *Leaf Traces* do not appear to come off very regularly. So far as we could judge from the evidence at our disposal, two or more leaf traces come off from the main axis and enter each leaf base, there subdividing and ramifying in several directions. Soon after the trace has left the central cylinder it consists of a small, fairly compact group of primary wood. This leaves a region in the main axis without primary wood for a vertical distance of about 6 mm. As the leaf trace goes further out it spreads laterally, and soon divides into two or three portions. In none of the leaf traces have any secondary elements been recognised, even in those quite near the main axis, and it is probable that the traces consisted entirely of primary wood, though behind the wood in some of the bigger traces are a few cells which look like soft-walled secondary elements. In each leaf base there are evidences of more than one trace, the different strands coming off at slightly different levels from the main axis. The numerous resin passages do not seem to lie in any particular connection with the leaf traces.

The Cortex.—No line can be drawn between the cortex and the leaf bases which enclose the stem. Phot. 8 shows the appearance of the tissues outside the main axis, which are composed of large, irregular, but closely packed parenchyma cells, mixed with which are stone cells similar to those in the pith. There are also numerous large resin passages which may bend irregularly in the tissue. In the older stems some of the resin passages are surrounded by a zone of thin-walled cells suggesting cambium, or a corky abscission layer (see *l.*, Phot. 19, Plate 4) round the resin canal. In some cases the canal contains only a structureless mass, presumably resin, while in others it is filled with cells which seem to be breaking down. We did not observe any of these canals with the epithelial lining layer which is usual in

the higher Gymnosperms. The stem was entirely clothed with leaf bases, and consequently has no periderm or epidermis of its own.

The Leaves.—The leaves were small and Cupressoid in appearance (see text-figs. 8 and 11), with a very broad base which enclosed one-half to one-third of the stem. The free part was thick, roughly ellipsoid in section, and relatively small and short in comparison with the adherent portion of the leaf. The leaves seem to have persisted for some time at any rate, for in the largest stem we have they persist, and are locally provided with thin layers of cork. That the leaves must grow considerably during their life is evident from the relatively great size of those round the larger stems as compared with those on the small twigs. Their phyllotaxy was not exactly determinable, but seems to have been a close spiral.

The *Epidermis* consists of small cells with thickened outer walls and no noteworthy character.

The *Stomates* lie only in the epidermis of the lower side of the leaf. So far we have observed none on the upper side, although this is the protected one and the lower surface is the exposed one, owing to the Cupressoid form of the foliage. At the very base of the leaf the stomates seem to be almost entirely absent, but over the rest of its under surface they are numerous. They are placed in rows, alternating with the sclerenchyma patches, as is seen in the transverse sections in text-fig. 11, A, *st.*, and in surface view in Phot. 9, Plate 3. They are numerous and often well preserved, and are cut in a variety of different directions, showing that the form of their guard cells is that typical of normal Gymnosperms (see PORSCH, 1905) and are but slightly sunk.

Sclerenchyma groups lie below the epidermis only on the lower side of the leaf, as can be seen in Photos 8, Plate 2, and text-fig. 11. The individual cells are small, very thick walled, fairly regular sclerenchyma of the kind which frequently forms hypodermal thickening in living plants. This hypodermal sclerenchyma differs from the patches of stone cells through the leaf tissues, the latter being much larger celled and rather stellate and irregular in form.

The *Ground Tissue* of the leaf is not distinctly differentiated into palisade and spongy tissue, but consists throughout of rather closely fitting cells with very small intercellular spaces. They thus differ from many living leaves of the Cupressoid type, in which the intercellular spaces are often very large. The cells on the lower side are more or less regularly arranged, and in some cases amount to a distinct palisade layer. This is principally to be seen in the smaller leaves of the young leafy twigs, for in the broad leaf bases of the older stems the arrangement of the cells is not so apparent. Running among the large irregular cells of the general mesophyll are numerous resin canals of various sizes, as well as single large cells which seem to have contained tannin or some resinous contents. There are also the large irregular stone cells, which may lie separately or in groups. In text-fig. 11, *scl.*, groups of these cells can be seen.

There are also many transfusion tracheids forming groups or zones (Phot. 8, Plate 2, *tr.*, and text-fig. 11, A), generally below the lower surface of the leaf. These will be considered specially after the vascular system has been described.

The Vascular System.—As was noted (p. 28), into each leaf base there enter two or three leaf traces which have practically no secondary tissue and whose wood is entirely centrifugal. In the leaf base proper they branch and divide, apparently with considerable irregularity, some strands continuing upwards and some running horizontally across the leaf base. This results in a network of vascular strands running through the base of the leaf, the bundles of which are orientated in a variety of directions, as can be seen in text-fig. 11, which is somewhat diagrammatic, but shows the true relations of the bundles. The three bundles arose from the division of a single leaf trace, the others opposite them from a different leaf trace. So far as we can judge from the few sections we have showing the detached portion of the leaf, the vascular bundles do not extend into it (see text-fig. 11, B). The individual bundles in the leaf base seem to retain the structure of the leaf trace bundles, and have no special sheath. The phloem is not distinguishable, owing to the crushing, but few wood elements with bordered pits were observed in the leaves, the tracheids being spiral or scalariform or with small simple pits. The diameter of the tracheids is very small, and in most cases their markings are far from distinct. Associated with the vascular strands, either running along beside them or appearing at their endings, are somewhat irregular scalariform tracheids.

In addition to these transfusion tissue cells definitely associated with the bundles, are groups of large numbers of transfusion tracheids in a more or less definite zone in the ground tissue of the larger leaves. This zone of cells can be seen in Phot. 8, *tr.*, and text-fig. 11, lying below the palisade-like layer on the underside of the leaf. In this position the zone of cells is recognisable in many of the leaves. In some cases more or less broken up into separate strands.

In the free part of the leaf it is not so apparent, and its cells are less typical, but groups of the tissue can be recognised at *tr.*, text-fig. 11, B, which seems to be the end strands into which the broad zone at the base of the leaf splits up as it approaches the tip.

A diagram of the leaf is given in text-fig. 11, showing the general distribution of all the tissues, both in the leaf base A and in the free portion B. This shows clearly the distribution of the vascular strands, which alone would seem to be inadequate to supply the leaf. As WORSDELL (1897) pointed out, transfusion tissue is differentiated from the mesophyll of Gymnosperm leaves to supplement the inadequate strand or strands. The whole structure of the leaf in *Yezonia* differs from that in any other Gymnosperm, but the physiological explanation of the unusual transfusion tissue is probably the same as for the already known types.

Affinities.—Judged purely from the anatomical peculiarities already described, apart from the suspicions we feel as regards its fructification, it is impossible to find

any family among Gymnosperms with which we can satisfactorily include this plant. That it is a Gymnosperm is proved by the character of the wood of the main axis, by the guard cells of the stomates, as well as by a variety of minor characters.

Let us consider one by one the features of this plant which are preserved in our material, and the lines of affinity which they severally indicate.

The pith with its rather large size and sclerised nests is not particularly remarkable. In the primary wood the entire absence of centripetal elements is like that of the higher Gymnosperms of to-day. The secondary wood (ignoring for the moment the irregularity of outline and the thick and thin walled zones, which are features peculiar to this fossil) is not Araucarian, because of the single row of pits on its walls; nor does it belong to the Pineæ in the sense of JEFFREY (1905), because of the absence of secretory canals in the wood; nor to the Taxineæ, because of the nature of the thickenings on the walls of the tracheids and of the nature of the medullary rays; but it is like the wood of the Abieteæ (in JEFFREY's sense), Cupressineæ or Taxodineæ. The apparent absence of stone cells in the phloem, however, cuts it off from several genera of the last.

In the nature of the secretory passages, in their great numbers, large size, irregularity, curving, and branching, *Yezonia* shows affinity with the Cycads. In all the families of the higher Gymnosperms the resin ducts, which are present in the leaves and cortex, are definite canals bounded by an epithelial lining, and in the leaves they take up definite and symmetrical positions in the tissue, so much so that the number and position of the resin ducts is taken as a detail of systematic value. In *Yezonia*, in no case could we observe anything like an epithelial lining in the passages, and it is with the irregular mucilage ducts of the Cycads that they can alone be compared.

In the external appearance of the foliage, with its small adpressed leaves, perhaps one can see a parallel to the genera of the Taxodineæ. Though in this description the general aspect of the foliage has been spoken of as Cupressoid, as a descriptive term popularly understood. The Cupressineæ proper have leaves in alternating pairs, which thus differ from those of the fossil, which are arranged in a close spiral. Nor is there any indication of anisophyly so commonly seen among the Cupressineæ.

In the leaf anatomy we can find no parallel among any known forms. All the Gymnosperm leaves, except those of the Araucarieæ, Podocarpeæ, and the Cycads are provided with only a single bundle, or a close pair as in *Pinus* and *Sciadopitys*. In the three former families the bundles are in a row along the lamina, but in the fossil we have an irregular scattered arrangement, with strands running in several directions, some even horizontally. The only type which reminds one of this arrangement at all is that of the Palæozoic genus *Medullosa*, though in it the whole structure is enormously more complicated and massive. The individual bundles of

the leaf in *Yezonia* differ entirely from those of *Medullosa*, the slight suggestion of similarity lying only in the scattered, irregular arrangement of the bundles, and in the way the leaf traces come off from different levels from the main axis to enter the leaf base.

The single bundle of the leaf is quite like that of any of the higher Gymnosperms with its small tracheids in more or less compact rows, all entirely centrifugal. The absence of all sign of a bundle sheath is unusual, however, for in most Gymnosperms bundle sheaths are more or less well developed, and are often very well differentiated.

The irregular masses of sclerenchyma and the large secretory canals so numerous in the leaf are not found in any plant we know.

The broad zone of transfusion tissue is a development peculiar to this plant.

We feel justified, therefore, in suggesting a new family of Gymnosperms in the coniferæ for this plant, the character of the wood taking it out of the Cycads and the foliage from Ginkgo. We are of course seriously hampered by the want of the reproductive organs. Part of a cone found in the same block, which contains several stems of *Yezonia*, may possibly be its fruit (see p. 40). If this should prove to be the case, the character of the cone is such as would seem to justify the foundation of a new family for the whole plant.

We have already pointed out the various families with which one or other characters of *Yezonia* may suggest comparison. With so many conflicting characters it is not easy to place it in the series of Gymnosperms as a whole, and we feel it wiser to reserve our judgment and content ourselves now with merely indicating the general synthetic character of the new type.

Diagnosis:—

YEZONIA, gen. nov.

Woody stem with secondary thickening. Tracheids with a single row of bordered pits, no secretory passages in the wood. Wood with thick-walled and thin-walled tracheids on the same radii, zones of secondary wood, very unequal, tending to lie on one side of the axis. Leaves closely adpressed, with broad base, short free part, and a number of vascular bundles in each leaf. Very numerous, large, irregular secretory passages throughout the leaves and cortex. Broad bands of transfusion tissue in the leaves. Wood entirely centrifugal in both stem and leaves. Medullary rays a single cell broad and one cell high. Branching infrequent.

Y. VULGARIS, sp. nov.

Axis flattened, pith large, with stone cells. Phloem with no stone cells. Leaf bases completely clothing the stem. Stomates in the leaves only on the lower sides, alternating with strands of sclerenchyma. Transfusion tissue in the leaves forming a broad band on the lower side of the leaves. Vascular bundles of the leaves orientated in a variety of directions, and dying out in the free tips of the leaves.

Upper Cretaceous, Hokkaido, Japan.

Yezostrobus Oliveri.

(Text-figs. 12, 13, and 14; fig. 8, Plate 1; Phot. 10-13, Plate 3.)

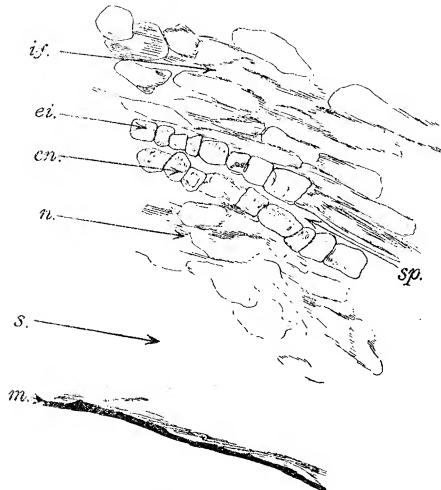
The slides 1 B 9 to 1 B 16 contain a series of sections through some seeds and sporophylls of this fructification. This block is the same as that from which the largest stem and many fragments of *Yezonia* are described, and contains also a variety of other plants. The fructification is incomplete, as it is represented only by five seeds and their scales, which are so arranged as to suggest that the complete fructification was a cone. In other blocks, a few fragments of the stone of the seed and more or less imperfect seeds are to be found, which, excepting the seed in block 1 Y A, will not be mentioned, beyond noting them as indications that the fructifications were fairly common.

The series in 1 B seem to be cut in an oblique angle through the cone, which appears also to have been crushed, so that the seeds and scales are cut in a variety of directions. In slide 1 B 14, a large seed attached to its scale is cut in almost perfect median longitudinal section. In this the seed is 7 mm. by 3·5 mm. in size. The other sections are cut in approximately tangential directions to the supposed axis, and show the seed and their scales in transverse oblique sections. Although we have not all the necessary data at our disposal, we have therefore enough to estimate with some degree of confidence the main features of the cone.

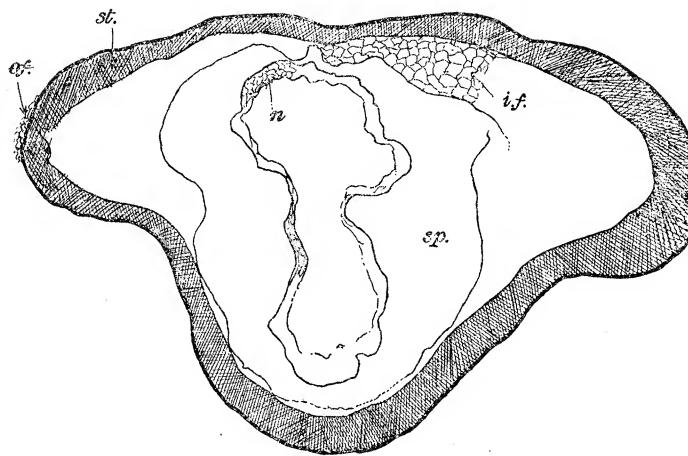
Form of Cone.—The way the seeds and scales lie closely fitting together, the edges of the scales overlapping, indicates that we have to deal with a portion of a cone. There is none of the axis present, but it would have lain in the direction X in Phot. 10, Plate 3. The seed in Phot. 10 being in nearly median longitudinal section, shows that the cone could not have been much less than 25 mm. in diameter, supposing, which is natural, that the cone were symmetrically radial.

The number of seeds on a scale is not determinable with positive certainty, but all the sections, both longitudinal and transverse, have only one seed to each scale, with no indication of a second, or even the place where a second might have been. In the longitudinal section the seed seems to lie in the middle of a fairly symmetrical scale. Although there is no indication of a second scale or ligule, it is not impossible that there may have been some small structure either at the base or the apex of the scale which escaped the sections. The diagram in the text-fig. 13 shows the seed and scale in what seems to be the true relation where a single seed lies in a median position on the scale.

The Seed.—Most of the sections are cut in rather oblique directions, but the longitudinal section passes through the vascular strand at the base of the seed, and also through the lower part of the micropylar canal, so that it barely misses being in a perfectly median direction. This section shows very clearly the most interesting feature of the seed, namely, that the nucellus and integument are not fused at all, but that the nucellus stands up freely in a space within the integument (see Phot. 11,



TEXT-FIG. 12.

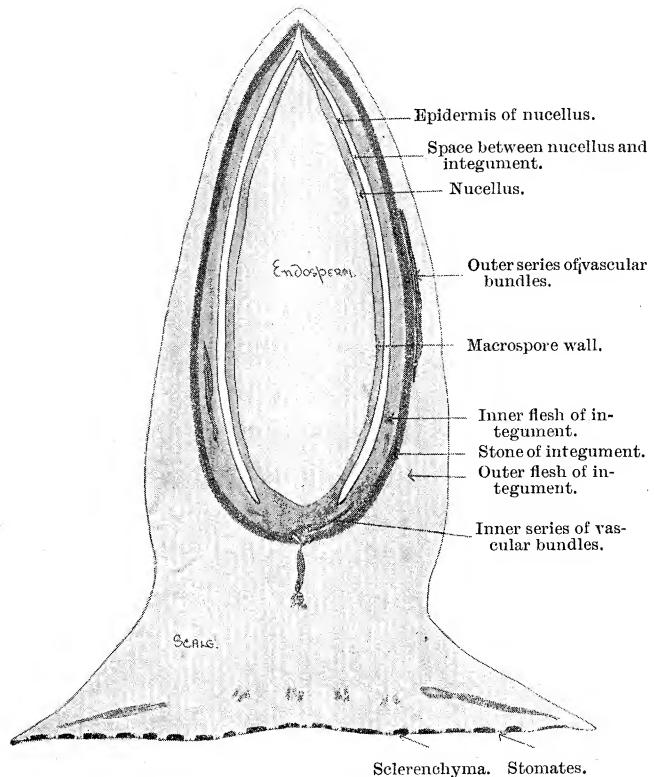


TEXT-FIG. 14.

TEXT-FIG. 12.—*Yezostrobus Oliveri*, STOPES and FUJII. Transverse Section of Internal Part of the Seed. if., Inner flesh of the integument; ei., epidermis of the inner flesh of integument; sp., space between the integument and the nucellus; en., epidermis of the nucellus; n., cells of the nucellus; s., space caused by decay and contraction of tissues; m., wall of macrospore.

TEXT-FIG. 14.—Transverse Sketch of Seed of *Yezostrobus*.

of., Fragment of the outer flesh remaining attached to st., the stone; if., the inner fleshy layers; sp., space between the epidermis of the inner flesh and the nucellus; n., the nucellus.



TEXT-FIG. 13.—Diagram of the Seed of *Yezostrobus*. This is partially restored. The micropyle is not given at the apex, as there is not evidence enough to determine its appearance. $\times 11$.

Plate 3, and text-fig. 12). Both the outer limit of the soft tissues of the integumentary "inner flesh" and of the nucellus are bounded by a well-defined, well-preserved epidermis layer. In this, our only longitudinal section, there is no sign of a pollen chamber, but, as can be seen in Phot. 12, Plate 3, the nucellus and endosperm project upwards into the base of the micropylar canal. This suggests two alternative possibilities for the structure of this region of the seed, the relative merits of which we cannot actually determine until we have more specimens. They are: either that the seed had passed the stage of pollination and that the growing tissues of the endosperm had crushed back the pollen chamber, which was presumably small, and are filling the whole available space in the integument; or, on the other hand, that the apical portion of the seed had a beak-like conical projection, within which lay the pollen chamber, which would be presumably rather small. If the seed were cut slightly obliquely, the section would escape such a pollen chamber and yet give an appearance of cutting the base of the micropyle; such a section, in fact, as the one we have.

The Nucellus.—In nearly all sections some of the cells of the nucellar tissue are preserved, and several specimens show a fine, large-celled tissue, instead of the crushed black line that so often represents the nucellus in fossil seeds. Something of this can be recognised in Phot. 11, Plate 3, but the detailed drawings in fig. 8, Plate 1, and text-fig. 12, show it more clearly. The best preserved part of the nucellus is the epidermis, which covers it entirely down to the base, where leaving about 2 mm. of the nucellus in contact with the soft tissues of the inner flesh, it is continuous with the epidermis of the latter. The cells are shown in longitudinal direction in fig. 8, Plate 1, where they are seen to be rather long, about 0·08 mm. by 0·02 mm., arranged with their long axes in the same direction as the long axis of the seed.

In transverse section these cells form a fairly regular skin of squarish cells with somewhat rounded corners, about 0·02 mm. in diameter. This layer is shown in text-fig. 12, *en.*, lying closer to the epidermis of the inner flesh than is usual. This figure illustrates the similarity of these cells to the epidermis of the inner flesh.

Careful search has been made for vascular strands or tracheids in the tissues of the nucellus. As the nucellus stood free within the integument they would appear to be almost a physiological necessity; while, further, one would expect them from analogy with the known types of Palaeozoic seeds (*cf. Stephanospermum* (OLIVER, 1904), for example), in which the nucellus stood free from the integument, and is invested with a number of tracheids. In none of the sections were we able to see any elements which were so preserved as to be clearly recognised as tracheids or vascular elements. Had they been present in numbers, some must surely have been petrified in a seed where much more delicate tissues are preserved and where the tracheids at the base of the seed are quite well preserved. Within the tissues of the nucellus, and contracted away from it, lies the macrospore wall (see *m.*, text-fig. 12, and Phot. 10,

Plate 3); a brown, prominent membrane, much corrugated. It is, in general, an opaque, structureless mass, but in a few places there are suggestions of pits in surface view, which one can presume (see THOMSON, 1905) were all over the membrane when it was living; from comparison with living forms, Dr. THOMSON's remark (p. 49), on concluding a short review of fossil seeds—"It is thus evident that, in these fossil seeds, the more primitive, Palaeozoic forms, have a much more prominent megasporic coat than the specialised and more recent Mesozoic ones, in which even the occurrence of a coat does not seem to have been demonstrated with certainty"—must now be modified. The membrane of the megasporic of this Mesozoic seed is entirely as pronounced as that of the Palaeozoic forms. As Dr. THOMSON remarks, the Mesozoic seeds hitherto known belong practically entirely to the *Bennettitales*, which we must recognise as very peculiar and standing rather apart from the other Gymnosperms he describes. We would suggest that when further specimens of Gymnospermic seeds are known from the Mesozoic, they may prove to have more or less thick membranes, as is the case in this specimen.

Within the membrane, but not filling it, in several seeds are a few cells which are undoubtedly *Endosperm*. This tissue is unfortunately very imperfect. It lies toward the apex of the nucellus, and where the cells are present at all they are only moderately preserved. The endosperm appears to have consisted of closely packed, undifferentiated parenchyma cells, 0·04 mm. in diameter. There is no indication of either embryo or archegonia.*

The Integument.—This is composed of three clearly defined and differentiated layers, much as in the case of the living Cycads (see STOPES, 1904). The outer fleshy layer is confluent with the sporophyll, and, as is seen in Phot. 10, Plate 3, it is not possible to draw any line of actual demarcation between them at the base of the seed. The stone layer is continuous round the base of the seed, and within it is the inner flesh which, in the oblique transverse section in slide 1 Y A, is seen to consist of several layers of thin-walled cells (see text-fig. 14).

The innermost layer of the integument is entirely soft celled, and the cells are rather long (see fig. 8, Plate 1) in the longitudinal direction of the seed. The layer is somewhat crushed in most sections, but in 1 Y A the cells are seen in transverse section with apparently no crushing, and seem to have been squarish or irregular in shape, and to have fitted into each other to form a closely packed, undifferentiated soft tissue. This is bounded on the inner side by a well-defined epidermis, seen in longitudinal section in fig. 8, Plate 1, and in transverse section in text-fig. 12. As in the case of the nucellar epidermis, the cells are much elongated in the longitudinal

* We saw in the endosperm tissue several appearances simulating some stages of karyokinesis. Owing to the fine granulation and crystallisation of the fossil matrix and other points, there is grave danger in accepting them as true fossil mitosis. Their position in the endosperm cells, however, makes it not impossible that they were really of that nature, and we see no argument against the view that petrified mitosis is perfectly possible.

direction of the seed, and squarish or round in transverse section. Their walls are thicker and darker than those of the general tissue of the inner flesh. No tracheal tissues were recognisable in the inner flesh except at the base of the seed.

The stone consists of very thick walled cells running in several directions throughout the layer, as is seen in fig. 8, Plate 1, and Phot. st. 11, Plate 3. There seem to be no definite zones of transversely and longitudinally running elements as are commonly found in the living Cycads (STOPES, 1904, p. 444), and as SCOTT and MASLEN, 1907, p. 109, describe for the Palaeozoic *Trigonocarpus*.

The stone as a whole is about 0·5 mm. thick, and is continuous and fairly uniform all round the seed except at the micropylar aperture. There appear to be no ridges or locally thickened regions such as are usual in Cycads and in the Palaeozoic types. The cells have an approximately circular outline when cut transversely, and have such thickened walls as to have very small lumina. In longitudinal direction they are long and somewhat irregular, and often show very beautifully the fine pit canals connecting cell with cell. The pitting and form of these cells is shown in fig. 9, Plate 1, which also illustrates the irregular mixture of transversely and longitudinally running elements. A few cells with blackened contents such as are seen in fig. 9, b., are scattered through the stone, but chiefly lie toward the outside, where they may mingle more or less irregularly with the outer flesh. At the apex of the seed there are more such cells than usual, and a few run nearly parallel to the micropyle.

The sarcotesta, or outer flesh, is composed of large, loosely packed cells, mixed with which run many elements with opaque brown contents which are suggestive of tannin cells. The tissue can be seen in text-fig. 14, *of.*, which shows its extent and nature towards the base of the seed. Further up the seed it is thinner, but in that region the layer is not perfectly preserved in any section. Outside the large soft-celled tissue of the flesh is a layer of fine elongated sclerenchyma cells which presumably lay under the epidermis. The latter is not quite determinable, although a thin crushed row of cells, to be seen in one or two places, may be epidermal.

In the layers of the outer flesh run a number of small vascular bundles, whose number is not quite certain. They do not cause any modification of the ground tissue in their region, having neither bundle sheaths, transfusion tissue, nor secretory canals associated with them so far as can be judged from the specimens we have.

The Vascular System.—There is evidence of a double vascular system in this seed, viz., a series of bundles in the outer flesh, and some tracheids in the inner flesh. Notwithstanding the fact that the nucellus stood free from the integument down to the base, there is no clear evidence of tracheal tissue in its layers. It is very probable, however, that there may have been a nucellar series of bundles, and their apparent absence in this plant may be due to a fault in the preservation.

The bundles in the integument do not show to advantage in the sections, and, indeed, can only be seen here and there. Apparently both the inner and outer

series sprang from a strand entering the base of the seed from the scale, but the evidence of the origin of the outer series is not complete, and it is very possible that, as in the case of modern Cycads, one or more additional branches from the sporophyll supplemented the one branch definitely destined for the base of the seed.

In the inner flesh the vascular tissue at the base of the seed can be seen at *t.*, Phot. 11, Plate 3. The diagram, text-fig. 13, is drawn only in outline, and shows the vascular strand coming toward the seed, and the tracheids inside the stone at the base of the inner flesh.

The bundles of the outer flesh can be seen in several sections, and in one section four distinct bundles lie in a little over one-third the circumference of the seed, so that presumably there were about a dozen strands altogether in the outer flesh. These bundles lie close to the stony layers, as is usual in living Cycads. They seem to have no special sheath or transfusion tracheids, and are just small groups of wood elements (which seem to be scalariform in longitudinal section) without any well-defined protoxylem (see Phot. 13, Plate 3).

The Scale.—The general character of the scale can be seen in Phot. 10, Plate 3, and text-fig. 13. The tissues of the middle and basal part of the scale are loosely built and large celled, with many brown cells which probably contained tannin. Between these scale tissues and the outer flesh no line of demarcation can be drawn. In the scale itself a few large, irregular stone cells, with very thickened walls are scattered through the tissues. The lower surface of the scale is bounded by an epidermis in which lie numerous stomata (see text-fig. 13). These alternate with hypodermic sclerenchyma patches. In some of the specimens a cork-like formation has arisen in several places owing to wounds, but in another, and apparently older cone of the same species, there is a thick cork layer continuous round the upper (*i.e.* inner and protected) part of the scale, and the protected part of the lower surface where the hypodermic sclerenchyma patches are not developed, which cork layer appears to be normal.

The vascular tissue is scattered throughout the scale, apparently in a very irregular manner, sometimes groups of two or three or even only one tracheid lying in the ground tissue. These elements are scalariform, many of them of rather irregular form, and much like transfusion tracheids. A stout strand of such elements runs right to the edge of the scale, accompanied by some long and narrow tracheids (see diagram in text-fig. 13). Toward the lower side of the scale run a number of strands of pitted and reticulated transfusion tissue which form a zone below the palisade layers.

The bundles are not definitely orientated, and though some elements are narrower than others it is difficult to locate any protoxylem. There is no evidence of true phloem, though a few small soft cells lie with the tracheids in the larger strands. There is no bundle sheath or accompanying secretory canal, and there seems to have been no secondary tissue, so that the strands are very simple.

The vascular bundle going to the base of the seed is only recognisable in longitudinal sections (see text-fig. 13), and it seems in no way different from the larger scale strands.

General Character of the Seed.—The most interesting feature of the seed is the clear evidence that it shows that the nucellus was free right to the base. Although this character seems to have existed in several Palæozoic seeds (see OLIVER, 1904, and SCOTT and MASLEN, 1907), it is much more clearly preserved in the present fossil. The general structure of the seed, with its massive, three-layered integument, is quite like the Cycadian type. At the same time these seeds are borne singly on scale-like sporophylls and in cones. Taking into consideration the character of the integument and the free nucellus, the organisation of this seed seems to be more like that of the Palæozoic form *Trigonocarpus* than any other individual seed. It lacks the characteristic ridges of the latter, and indeed there is no close or direct connection suggested between them. There is some resemblance also to the Araucarias, with a single seed on a scale, though here the massive complexity of the fossil separates the two.

If one considers the integument alone, it is seen to resemble entirely that of the modern Cycads (*cf.* STOPES, 1904, fig. 1), except that the stone seems to have had no ridges at all, though it is not impossible that there were small ridges at the apex which have escaped the sections at present available.

As regards the pollen chamber, it only appears evident that the pollen chamber could not have been of a large size like those of *Stephanospermum* and other Palæozoic types.

There is no evidence of a separation layer at the base of the seed, and the tissues appear moderately mature; but it might not have been quite ripe, so that we cannot tell whether or not it was separated from the scale, or whether the cone itself broke up into separate scales as it ripened.

Affinities.—The structure of this cone is, without question, different from that of any living genus. It is difficult to say whether it can be justly included in any living family.

The general organisation of the seed itself, apart from the free nucellus, is so similar to that of the Cycads as to suggest direct connection with them. Taking the free nucellus into account, *Trigonocarpus* seems to come closer to the fossil form we are now describing than any other described form. These not impossible lines of affinity are complicated by the fact that the seeds were borne singly on scale-like sporophylls which were united to form a cone. The scale appears to have been a simple one, not like that in *Araucaria*, where there is a ligule, and, further, the relation of seed and scale is not like that in *Araucaria*.

As there is no family, either recent or fossil, in which we can include this fructification, we feel that we are not going too far in founding a new family for the plant, which would be among the simplest Coniferæ. Of course, the vegetative

characters should be taken into account in taking such a step, but unfortunately there are none in organic connection with the cone. Owing to certain suspicions, founded on what seems good evidence, we incline to believe that the vegetative organs also had unique features.

Possible Vegetative Organs.—We have no trace of the axis of the cone or of vegetative parts in organic continuity with the cone, nor has it any very distinctive feature, such as peculiar hairs or glands, which would make the identification of its parts absolutely certain. There are, however, the following good grounds for suspecting that *Yezonia* is the vegetative part of the plant.

The grounds are :—A, Association ; B, points of structural similarity.

Association.—As was noted (p. 23), *Yezonia* is the commonest plant of the flora we are now describing. This seed (or fractions of it) is also the commonest fructification. Further, it is in block 1 B, in which there are three distinct stems of *Yezonia* and numerous leafy twigs of the same plant, that the cone with the principal seeds lies.

Points of Structural Similarity.—These lie in the scale as compared with the foliage leaf. Compare the surface of the leaf in diagram 11 with that of the scale in text-fig. 13. They have an almost identical similarity in the arrangement of stomates and alternating hypodermic sclerenchyma strands on the lower side of the scale and leaf. In the histology of the assimilating layers of the leaf and scale; in the sclerenchyma cells; in the stomates; in the large irregular stone cells, of which there are a few in the cone scales and many in the leaf; in the irregular secretory passages without epithelial lining, of which there are few in the scale and many in the leaf; in the presence of scattered irregular vascular strands in each case; and in the presence of a large quantity of transmutation elements there is complete detailed similarity between the tissues of the leaf and of the scale. For these reasons we think it very possible that the two parts really form one plant, which in that case, having both its vegetative and reproductive parts of a new type, would entirely justify the foundation of a new family to include it.

Diagnosis:—

YEZOSTROBUS, gen. nov.

A cone, presumably radially symmetrical, with scales and seeds attached. The cone scales simple, without ligule, and with numerous scattered vascular bundles, each scale bearing in the middle a single seed. Seed integument massive, with an outer flesh, middle stone, and inner flesh. Vascular tissue present in both the outer and inner flesh. Nucellus free to the base, with a well-marked epidermis lining the inner flesh and the outside of the nucellus. Pollen chamber presumably small.

Y. OLIVERI, sp. nov.

Cone about 25 mm. in diameter. Seeds 7 mm. \times $3\frac{1}{2}$ mm., the outer flesh with numerous secretory cells. Stone simple, and uniform from base to apex. Epidermal

lining of the inner flesh and the nucellus composed of cells elongated in the direction of the long axis of the seed. No sharp distinction between the base of the outer flesh and the scale.

Upper Cretaceous, Hokkaido, Japan.

Araucarioxylon Tankoense.

(Phot. 17 and 18, Plate 3.)

Of this species we have one specimen, a small portion of the secondary wood of one annual ring. From this transverse sections 1 Y 1 to 1 Y 8 were cut, and longitudinal sections 1 Y 13 and 1 Y 12. The preservation is not very good throughout the tissue, and there are a number of bore holes about 5 mm. in diameter which have removed the tissue completely, though some regions are excellently petrified (see Phot. 17, Plate 3).

In many of the cells in transverse section the pittings can be well seen in the radial, oblique, and sometimes tangential walls, even with the low power. These pittings are in two, three, or four rows in each wall, and alone suffice to indicate the nature of the wood. They are seen in Phot. 18, Plate 3, as they appear under the high power. In the wood there are no resin canals, nor does there appear to be any resin parenchyma. There are numerous black masses filling some of the tracheids and medullary cells, which suggest in some cases the possibility of resin-containing cells being concealed by them, though none are determinable. The medullary ray cells are numerous, and lie between every two or three rows of wood elements.

The longitudinal sections are so poorly preserved that little can be seen in them beyond the pittings on the tracheal walls and the number of the cells in the medullary ray. The alternating rows of bordered pits with hexagonal outline are perfectly characteristic of *Araucarioxylon*. The medullary rays seem to be from three to six cells in height.

Affinities.—The character of the tracheids suffices to place this wood in the group *Araucarioxylon Kraus*. The alternating, many rowed, hexagonal bordered pits being entirely characteristic, as are the medullary rays and absence of resin ducts, and though only part of one annual ring is present, its considerable width is a further point of similarity with the type.

So far as we are aware, this genus has not yet been recorded for Japan, but too little of the plant is preserved to allow of a detailed consideration of its habit or close affinities.

The specific name *Tankoense* is given in honour of the Tanko Kwaisha, in Hokkaido, to whose hospitality we owe much while collecting on their ground.

Diagnosis:—*ARAUCARIOXYLON TANKOENSE*, sp. nov.

Annual rings broad. Tracheids square in transverse section, locally slightly irregular. Pitting on oblique, radial, and a few tangential walls. From two to five rows of pits in each tracheal wall. Medullary rays single rows, three to six cells in height.

Upper Cretaceous of Hokkaido, Japan.

Cedroxylon Matsumurae.

(Fig. 10, Plate 1; Phot. 20–23, Plate 4.)

Of this species we have two small specimens and part of a large trunk. The best preserved of these occurred in a small block unassociated with any other plant fragments. (See Phot. 20, Plate 4.)

The secondary wood alone is preserved, and only a small portion of that, viz., a compact oblong splint, about half a square inch in section. From this five transverse sections, 1 X 1 to 1 X 5, were cut, and from the remaining portion five longitudinal sections, 1 X 11 to 1 X 15. As the cells are considerably crushed in some cases, the same longitudinal sections show both tangential and radial views of the medullary rays. The second specimen is a large trunk, and is not complete, showing only secondary wood, but it indicates that the tree must have been of considerable size. The part which is present is 60 cm. in diameter, containing about 65 annual rings. A small portion of the block was cut in slides, KF 11 K 3–4, from which the stem was determined.

As in all cases there is nothing but secondary wood, it is impossible to form any idea of the habit or immediate affinities of the plant. The wood can be placed in one of the groups of Gymnosperms known only from their secondary woods, which groups, however, are well known to have no true generic value.

The *Annual Rings* are clearly marked (see Phot. 20, Plate 4), but are very variable in extent. In specimen 10, two adjacent rings contain respectively 80 and 11 tracheids in the same radius. The average, however, is about 20 or 25 elements in each radial row. The autumn tracheids are about one-fifth to one-half of the diameter of the spring elements, and number four to six in each ring. The spring elements are roughly square in section (see Phot. 21, Plate 4).

The *Medullary Rays* are numerous and narrow, and the cells composing them are not very well preserved. They can be seen in Phot. 23. Sometimes they lie between each pair of tracheids, sometimes between four or five wood elements. In transverse sections they appear to be only a single row of cells in breadth. In the better preserved portions they are so petrified as to give a suggestion of protoplasmic contents, and even of nuclei (*cf.* long. sect., fig. 10, Plate 1). In poorly preserved parts they are filled with blackened contents, which cannot, however, be taken to

indicate resin parenchyma, as the tracheids are also filled with similar carbonised masses where their preservation is poor.

Both in the wood, and so far as we can ascertain from the limited material at our disposal, in the medullary rays, all resinous cells are normally absent.

In *Longitudinal Sections* of specimen 1 X the pittings on the walls of the tracheids are clearly seen. In many cases the pits are in a single row, but there are also frequent cases of double rows on the tracheids, in which case they are rather irregularly arranged, sometimes opposite and sometimes alternate, but never quite confluent (see Phot. 22, Plate 4). The individual pits are round, clearly bordered, and apparently with a round, not slit-like, opening, though the fossil is not quite well enough preserved to determine this point absolutely. The pits appear to be uniform in size, and not so irregular as those described for *Cupressinoxylon*. The tangential view of the medullary rays (Phot. 23, Plate 4) shows that they are one cell broad, and average from .5 to 12 cells in height, though many are more, even up to 20. In the radial direction the cells are not differentiated as they are in *Pinus*, but form bands of simple oblong cells. Pittings are suggested in some cell walls, and appear to be round pits much of the size of those in the wood. In parts of the section where the preservation is particularly good, the appearance of protoplasmic contents and nuclei in these cells is very clear (see fig. 10, Plate 1). Such may be only a fortuitous chance of preservation, but they may well show the real cell contents truly petrified. In either case they are sufficiently rare in all but the best preserved material to make them of interest in this wood fragment, which, on the whole, is far from well preserved.

Affinities.—The lack of resin canals in the wood immediately separates the plant from the Abietinean type of *Pityoxylon*, while the pitting on the walls separates it from *Araucarioxylon* and from *Taxoxylon*. There remains then but *Cedroxylon* and *Cupressinoxylon*, to either of which it might belong. In SCHIMPER and SCHENK's classification (see ZITTEL, 1891, p. 862) the chief difference between these two types of wood, whose separation is not very distinct, lies in the quantity of resin parenchyma: the former containing little or none, and the latter much. As we could not detect any resin parenchyma in the fossil, this indicates that it belongs to the *Cedroxylon* type. GOTCHAN (1905) has pointed out the difficulty that often occurs in the separating of these two genera, unless the pitting of the medullary rays be taken as an index. Though our fossil is not well enough preserved to show this decisively, the round form of the pits agrees with the *Cedroxylon* type. Further, in minor detail it agrees with *Cedroxylon* in the placing of the pits on the walls of the tracheids, and in its broad annual rings.

Specifically, it appears to be distinct from those hitherto described. The only species of this genus which has been described from the Cretaceous of Japan from structural material seems to be *C. inaequale*, a species with a distinctive character in its medullary rays (described by REISS, 1907).

The specific name is given in honour of Prof. MATSUMURA, in whose department most of our work has been done.

Diagnosis:—

CEDROXYLON MATSUMURÆ, sp. nov.

In the secondary wood the annual rings are well marked, broad, but often very irregular. Average size of spring tracheids, 0·04 to 0·05 mm. Autumn wood one-fifth to one-half the diameter of the spring tracheids. Tracheids with round bordered pits, sometimes in two irregular rows. Resin parenchyma absent. Medullary rays single cell rows, generally 5 to 12 cells in height, but may be as many as 20.

Upper Cretaceous, Hokkaido, Japan.

Cedroxylon Yendoi.

(Phot. 24, 25, and 26, Plate 4.)

Of this species we have one specimen, in a block from Yubari which contains no other plant fragments. It is cut transversely in slides 1 ZD 1 to 1 ZD 11, and longitudinally 1 ZD 1 D to 1 ZD 14. The stem is now 5 cm. in diameter, and was probably larger, for it is very much bored by marine organisms, and there is no trace of bark or cortical tissues. There are 35 clear annual rings, varying somewhat in breadth but fairly regular. The stem shows no striking peculiarities, and is considered to belong to the genus *Cedroxylon* on much the same grounds as is the previous species.

There is one noteworthy feature, however, namely, the presence of wound-caused resin ducts in the wood. As is well known, one of the principal characters used in the determination of the "genus" *Cedroxylon* among fossil woods is the absence of resin ducts in the woody zones. This feature is also, of course, characteristic of the living genus *Cedrus*, but JEFFREY's work on the resin ducts of the living Gymnosperms showed that, as a result of wounding, resin ducts are produced in genera which are otherwise without them in their secondary wood. This he also found to hold good, even for the fossil genus *Araucarioxylon*, from which is described a wounded stem with a row of traumatic resin canals (HOLICK and JEFFREY, 1906, Plate 5, figs. 5 and 6) in the secondary wood. With these figures of fossil wound-caused resin ducts those in our plant agree absolutely. As they are found only here and there in the stem, and are not a constant feature of the wood, there seems no reason to doubt that they are also the result of injury. Their appearance is shown in Phot. 24, Plate 4, in transverse section.

In the living plants, JEFFREY notes that as well as these vertically running canals in the wood, there are a few horizontally running canals following the medullary rays. One such case in *Cedrus deodara* he figures (JEFFREY, 1905, fig. 40, Plate 5) in transverse section, showing both vertically and horizontally running canals.

In our fossil we have not seen the horizontally running canals in transverse section, but in a tangential section of the wood a group of several medullary cells can be seen in which there are resin ducts, cut in a transverse direction of the ray duct in a tangential section of the ray. This is shown in Phot. 25, Plate 4. These sections give some indication of an epithelial lining to the resin canal, which is not easy to see in transverse sections of those running in the wood because the preservation is far from perfect. These seem to be the first recorded traumatic resin canals for the genus *Cedroxylon*.

As regards the specific determination of this fossil, we rely chiefly on the appearance of the tangential longitudinal section through the wood for the grounds for separating it from *C. Matsumuræ*. In the former the medullary rays are very numerous and generally from 5 to 12 cells and not infrequently as many as 20 or more cells in vertical height. While in the present plant some of the medullary rays have as many as 8 to 10 cells (see Phot. 26, Plate 4), but they generally average from 3 to 5 cells in vertical height. In transverse section the average size of the tracheids in this species is also distinctly less than in *Matsumuræ*, while the tracheids more commonly have two rows of bordered pits. In this fossil also the annual rings are narrower and more regular than in *C. Matsumuræ*. Further, in this fossil we have the traumatic resin canals. Though we are well aware that such criteria are not very reliable when we cannot be sure that the plants were growing under the same conditions; taken all together they favour the view that the species are distinct.

We have named the species after Prof. YENDO, of Sapporo University, to whom both the authors are much indebted for assistance in obtaining material.

Cunninghamiostrobus yubariensis.

(Text-figs. 15, 16, and 17; Phot. 27-34, Plate 5.)

The only specimen of this plant we have obtained hitherto is an unattached cone, from which the seeds appear to have been shed. The specimen is not complete, and was lying in the nodule so that it penetrated the surface obliquely, where the stone had been somewhat smoothed by water wear, thus giving an external view similar to an impression. This is seen in its natural size in Phot. 27, Plate 5.

The sections are catalogued as 21 C 1-21 C 4, and include oblique sections of the axis, and a number of scales, attached and free, cut in various directions.

The mature nature of the tissues, the absence of seeds which were presumably dehisced, and the open scales, indicate that the cone was ripe before petrification and that it was not one of those types (like *Araucaria* and *Abies*) in which the scales fall away from the axis together with the seeds. It appears to have been about 2 cm. by 3 cm. in size, with an axis of from 4 mm. to 5 mm. in diameter.

As there is no indication of seed structure except for the rather problematical aborted ovules in slide 21 C 2, we have had to depend entirely on the anatomical

details of axis and scales for indications of the affinities of the cone. These are, fortunately, sufficiently characteristic for apparently sound conclusions to be drawn from them.

The Scales.—An individual scale appears to have measured 9 mm. or 10 mm. across from edge to edge of its wing-like expansion, with a central thickness of 2 mm. which rapidly thinned out laterally. The outline of several scales is shown in text-fig. 15, where diagram A is taken from the level at which the seeds appear to have been attached. Near the base the scales were less expanded than they were further from their attachment to the axis.

There is no indication whatever of a double scale comparable with that of the Abietineæ, or of a ligule, other than the irregular pad of tissue which is seen in the text-fig. 15, A and B at p., which appears to have extended some distance across the scale when but a little further from the axis, and to have formed a low outgrowth on the upper surface. The edge of this is seen cut slightly obliquely at e. in c, which should be compared with the diagram of a section of the living *Cunninghamia* shown in text-fig. 15, D. The general external appearance of the individual scale was therefore in all probability not unlike those of recent *Cunninghamia*, though the latter are slightly larger and more fleshy, while the former had more strengthening tissue and were more pointed at the apex. Phot. 29, Plate 5, shows an actual scale of the fossil.

The *Epidermis* of the scale, though not perfectly preserved in every case, is sufficiently well represented to show that it surrounded the entire scale except on the irregular part of the pad (p. in B, text-fig. 15, and Phot. 29, Plate 5), where presumably the seed was attached. The cells were small, regular, and provided with a thick outer wall.

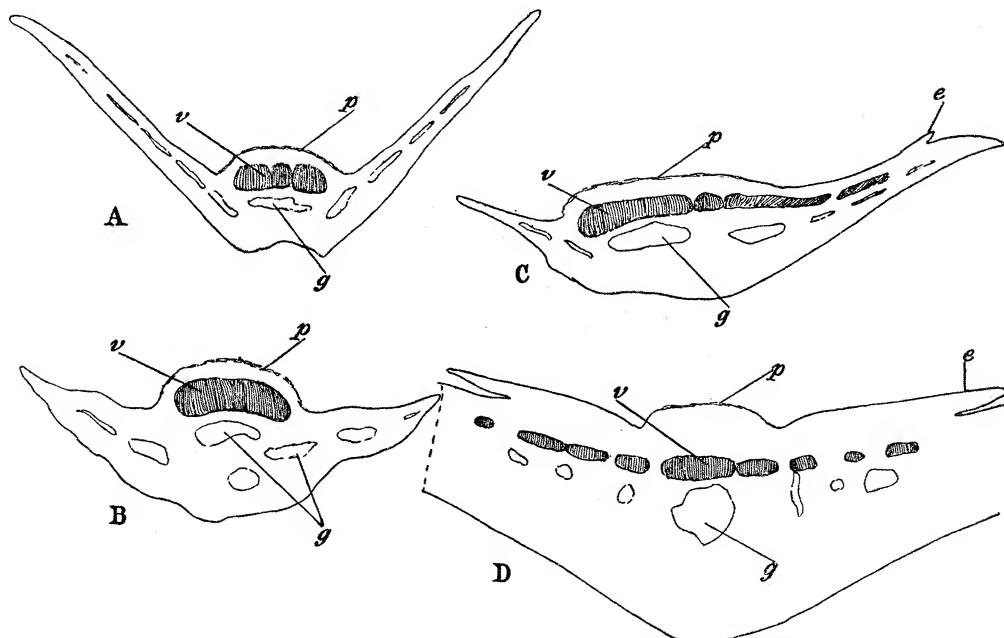
The *Hypoderm* was somewhat irregular, usually consisting of two rows of elongated, sclerised cells, with small lumina on the lower surface of the scale, and of a single layer of more rounded cells below the upper epidermis (see h., Phot. 28, Plate 5).

Stomates were present in large numbers in parts of the scales, particularly the central region of the expansion, where they were crowded in bands alternating with the sclerised hypoderm. They were sunken, and of normal Gymnosperm type, opening into the soft mesophyll, which in their neighbourhood replaces the sclerised cells lying elsewhere below the epidermis.

The *Ground Tissue* of the scales consisted of roundish, thin-walled cells, among which were scattered a few isolated sclerenchyma cells, and through which a number of

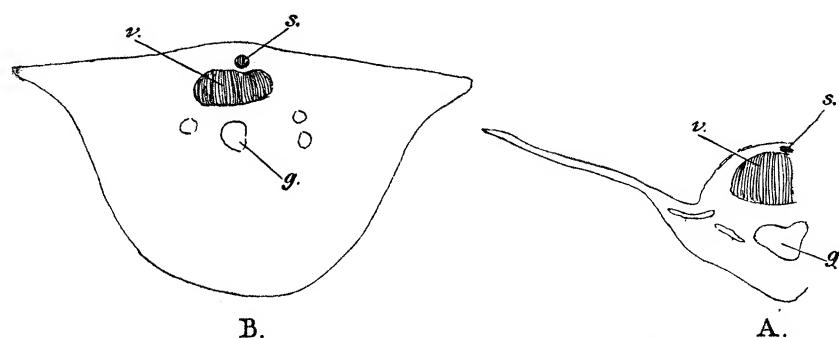
Resin Ducts were scattered. These were naturally irregularly arranged, but the larger ones tended to form a single row across the scale, and toward the base of the scale, where there was the single large vascular strand, there was a main duct just below it, as is the case also in the living *Cunninghamia* (see diagrams in text-figs. 15 and 16, g., and Phot. 30, Plate 5).

The vascular supply of the scale entered as a single strand of remarkably large size (see diagram text-fig. 15, B, v.). The bundle was normally orientated, with the protoxylem on the upper surface. This is indicated by the position of the cambium and the form of the medullary rays and the bundle in general, as no actual protoxylems are recognisable. The large bundle broadens laterally, and partially



TEXT-FIG. 15.—A, B, and C, Diagrams of the Cone Scales of *Cunninghamiostrobus*. D, Diagram of Cone Scale of living *Cunninghamia* for comparison.

v., vascular strand; g., secretory canals; p., pad of tissue on which the seeds are situated; e., edge of the pad or ligule-like extension.



TEXT-FIG. 16.—Cone Scales. A, *Cunninghamiostrobus*; B, Living *Cunninghamia*.
g., secretory passages; v., vascular strand of the scale, from which s. goes out to the ovule.

divides, travelling thus for some distance up the scale, when it divides and subdivides into a series of bundles, all normally orientated, which runs across the scale (see fig. 15, c, and Phot. 28, Plate 5). There were no irregularly orientated, reversed, or circular bundles such as are found in the *Araucarieæ* (see SEWARD and FORD, 1905) and the *Abietineæ*. In one scale only was there a small strand associated with the

main bundle, very close to the protoxylems (see Phot. 30, *s.*, and text-fig. 16, *s.*). This occurs just about the level where the seeds were presumably attached, and was in all probability the strand going out to supply an ovule. The diagram of *Cunninghamia* (text-fig. 16, *b*), shows a similar condition, though the branch strand is relatively larger than in the fossil. In the living plant three strands run off in this manner, one to each ovule, but in many of the sections one strand only is cut in this position, as they come off at slightly different levels. Consequently the fact that only one branch strand has been observed in the fossil cone has no weight in favour of the view that there might have been only one seed to each scale.

Between the bundles which form a series across the distal end of the scale are groups of connecting transfusion tissue (see Phot. 28, Plate 5, *t.*), which both as to size, form, and position are paralleled in *Cunninghamia*. These cells in the fossil show round, apparently bordered, pits, in some cases, and in others a large irregularly meshed network thickening (see Phot. 31, Plate 5). In all the bundles there is almost no trace of phloem, though there are a few soft crushed cells behind a cambium-like zone that indicate that at least a few such cells existed. The mass of the bundle consisted of closely-packed, thick-walled tracheids of small size, as can be seen in Phot. 33, *v.*

The attachment of the seeds to the scale was, without doubt, in the region of the pad of tissue previously mentioned (*p.*, text-fig. 15); here the epidermis and sclerised hypoderm stop short, and its irregular surface seems to lie limited by a zone of much-crushed cells, which are very thin walled and devoid of contents, suggesting a corky separation layer. They are not very well preserved, however, and in these cases there is nothing to indicate the number of seeds which belonged to each. The only suggestion afforded by the fossil (apart from the analogy with *Cunninghamia* which it presents) as to the number of seeds lies in the problematical structures at the apex, which are very like aborted ovules at the tip of the cone. These are seen in Phot. 32, Plate 5, and there the likeness to ovules which have been cut in oblique tangential section is apparent. In this figure *a* and *b*, which are distinct protuberances, are attached in a central position on the upper part of the scale. At *c* the scale shows an irregularity which may be a very tangential section of a third ovule.

In Phot. 33, Plate 5, is a high-power illustration of the supposed ovule *a*, which shows the character and arrangement of the cells composing it. These resemble more closely those found in a tangential section of an ovule than they do the mesophyll tissue of a scale. The general tissues of this scale are not so mature and hardened, nor is there the same development of vascular tissues as in the ripe scales from which the seeds have fallen; facts which support the view that the structures under discussion are aborted organs. Such aborted ovules not infrequently occur at the tips of living cones, so that it is natural enough that they should be found in fossil material.

While from their somewhat problematical nature these structures do not determine

the question of the number of seeds borne by each scale, yet they are not at variance with, and indeed rather lend additional support to, the view that the number was three, or at any rate not less than two.

The Axis.—There is but one section of the axis, 21 C 1, which is cut obliquely. The diameter of the vascular tissue is about 2 mm., of which the pith occupies about one-half; the cortical tissues are too poorly preserved to be accurately estimated. The woody tissue is cut very obliquely, and there are several strands going out to the scales, which are cut in different directions.

The *Pith*, about 1 mm. in diameter, consists of a homogeneous mass of rather large roundish cells, closely packed so as to leave practically no intercellular spaces. These cells extend for some distance into the primary medullary rays, which are broad at their commencement.

The *Protoxylems*, of which ten groups can be recognised, are cut so obliquely as to show their spiral thickenings. There appears to have been about half a dozen or more cells in each group.

The *Secondary Wood* is small celled, but though cut obliquely there are no walls which show any pittings. This is due to the preservation, which is poor, but on the branch bundle going out to a scale a few of the tracheids have round bordered pits in a single row, placed at some distance from each other.

The *Medullary Rays* are broad in contact with the pith, but soon narrow down to a single row, usually one, two, or three cells in height, as is seen in longitudinal tangential sections of strands going off to the scales.

Cambium and *Phloem* are too poorly preserved to be recognised, except outside one strand, which is cut nearly transversely, and where they are very crushed.

The *Scale Bundles* going off from the main axis carry a group of protoxylem and a large fan of secondary tissue. One of these is seen in transverse section in Phot. 34, plate 5. Set at this level the wood, though radiating from the protoxylem in the normal direction, forms an almost circular mass, which spreads out and becomes oval as it enters the scale, where it runs undivided for some distance.

The *Cortex* consists of tissue like that forming the groundwork of the scales, with the addition of a much larger proportion of the large isolated sclerenchyma cells, which are like those in the living *C. Konishii*. There are numerous big resin ducts which break up the tissues considerably. The limit between scale and cortex is not defined at all clearly.

Morphology.—In the description of the fossil, reference has been made to the likeness between it and the genus *Cunninghamia*, particularly in the character of the scales. This is self-evident from the diagrams shown in text-figs. 15 and 16. To enter into a full consideration of the morphological value of the fossil scales would therefore entail a consideration of those of *Cunninghamia* also, which we are not prepared to do in this place. There are, however, one or two points which may be noted. To make the form of the fossil scales clear we must consider them in radial

section. In text-fig. 15, c and d, the pad of tissue previously mentioned is shown as it appears in sections cut transversely across the scale, that is, in a tangential direction as regards the whole cone. They are cut in that very narrow region where the flap of tissue is developed, and as a result it appears to have a far greater importance in relation to the whole scale than it has in actual fact. In a view of the surface of the whole scale, the flap would be seen to be actually a very small structure which lies

only in the immediate region of the attachment of the seeds. As *Cunninghamia* is not a very accessible genus, and we know of no such figure in the literature, a radial section of the scale showing the true relation of scale and flap and the position of the vascular strands may be useful (see text-fig. 17). This diagram represents also the essentials in the fossil scale.

SACHS, and later EICHLER, have described the case in *Cunninghamia*, stating that a single bundle enters the scale and that three small bundles pass off from it with inverted orientation, one to each ovule; thus considering that no inner scale is present, and there is but a single leaf with the small transverse ridge as a ligule.

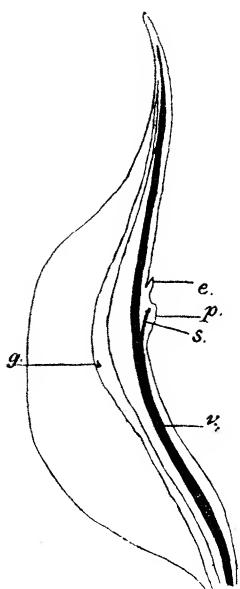
The Araucarias (EICHLER, in ENGLER's 'Pflanzenfamilien,' speaking of the Taxodineæ, says: "Diese Gruppe ist nicht sehr natürlich, und bietet durch Vermittelung von *Cunninghamia* Uebergänge zu den Araucariinæ") have an elaborate scale anatomy with numerous strands in inverted orientation (see SEWARD and FORD, '05, p. 363). Notwithstanding this vascular complexity, SEWARD and FORD lean towards describing them as "simple structures homologous with leaves" (p. 355). In *Cunninghamia* and our new genus, which we are calling *Cunninghamiostrobus*, the scale anatomy is much simpler, having only one row of normally orientated bundles with very small strands going out to the ovules, and hence there seems even more justification for a direct and simple description.

TEXT-FIG. 17.—Longitudinal Diagram of Scale Arrangement in *Cunninghamia*. Compare the parts with the transverse section.

v., vascular strand; s., small strand going off to the ovule; p., pad on which ovules lie; e., edge of pad; g., secretory canals.

orientated bundles with very small strands going out to the ovules, and hence there seems even more justification for a direct and simple description.

Affinities.—The simple nature of the individual scales, the large single bundle at their attachment, which bundle breaks up into a row of normally orientated strands, were data sufficient for the separation of this cone from both the *Araucarieæ* and the *Abietineæ*, with either of which it might be compared as regards its external features. The internal anatomy, however, is a sure guide, and after examining the cones and the literature relating to them—of the other possible genera of Gymnosperms—it became evident that the likeness between the fossil and the genus *Cunninghamia* (until recently considered monotypic) was considerable. The lack of information regarding the seeds and vegetative parts of the fossil makes it impossible to speak



decisively, but as the scales and axes agree so closely, it seems natural to conclude that the genera must stand very near to each other, hence the name *Cunninghamiostrobus*.

The recently described second species of *Cunninghamia*, *C. Konishii*, was examined, from which we were fortunate enough to be able to make sections, as Dr. HAYATA, who originally described the plant, very kindly placed a dried cone scale at our disposal. In size and general appearance, when in section, this appears remarkably similar to the fossil, though the scale, as a whole, is smaller and blunter. In the tissues of the scale of *C. Konishii* are many large round sclerised cells like those noted in the fossil cortex and at the base of the fossil scales, while there is also a sclerised hypoderm all round the scale which is not unlike that in the fossil. *C. sinensis* scales, on the other hand, are larger and fleshier, and have not these sclerised tissues so much developed. The entire cone of *C. Konishii* is smaller than that of the fossil, while that of *C. sinensis* is larger.

Among structurally preserved fossils, so far as we are aware, no specimens of this affinity have ever been described, but the general appearance of the cone, as seen in Phot. 27, is such that it is not unlikely that some of the impressions known as *Sequoia*, for example, may in reality be those of *Cunninghamiostrobus*. In HEER'S paper on the Cretaceous flora of the Arctic, a number of impressions of "Sequoia" are figured, several of which are very like our Phot. 29 (see HEER, 1874).

Fossil fragments described as belonging to the family of *Cunninghamia* consist only of twigs with some remains of foliage attached. Of these several species have been described from the Upper Cretaceous of various parts of Europe. What relation these fossils bear to the cone just described it is difficult to say, for not only is there the natural uncertainty of connection between a fossil cone known by its anatomical structure and foliage impressions found in another continent, but there is added to it the unsatisfactory nature of the foliage impressions themselves, which seem in most cases to lack the reliable characters of the leaves of the living form. While all the leaf and stem impressions are of such a fragmentary and rather uncertain nature, *Cunninghamiostrobus* offers really reliable evidence in the detailed structure of its fructification that plants related to *Cunninghamia* were living in the Cretaceous period.

The fact that the living genus *Cunninghamia* was only known to have one species for so long and now has but two, both growing in restricted areas, is in itself highly suggestive of either the antiquity or the extreme youth of the genus. The discovery of the fossil cone in the Cretaceous, so closely resembling that of the living species in its anatomical structure, rather favours the view of the antiquity of its origin.

Diagnosis:—

CUNNINGHAMIOSTROBUS, gen. nov.

Cone scales and axis in anatomical essentials like those of the living genus *Cunninghamia*.

CUNNINGHAMIASTROBUS YUBARIENSIS, sp. nov.

Cone intermediate in size between *Cunninghamia sinensis* and *C. Konishii*. Scales less pointed than in the former. In general shape more like *C. sinensis* than *C. Konishii*. Vascular strand of the scale very large and ovular strand small. Large resin ducts constantly associated with the vascular strand. Hypoderm well developed. Large isolated sclerenchymatous cells, few in number.

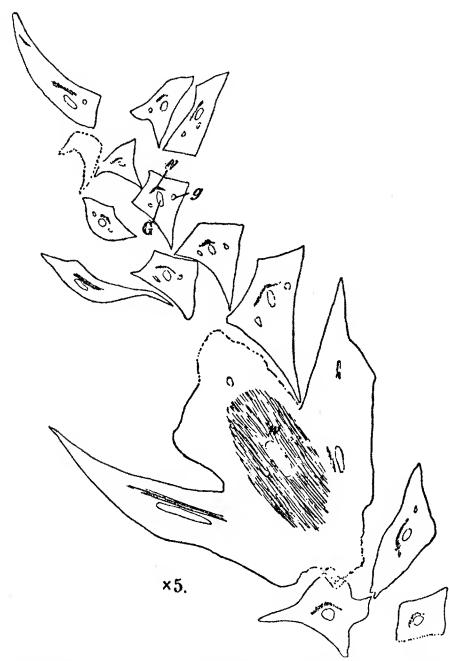
Upper Cretaceous from Hokkaido, Japan.

Cryptomeriopsis antiqua.

(Fig. 11, Plate 1; Photos. 35-41, Plate 6; and text-fig. 18.)

Three blocks have yielded specimens of this plant, two from nodules found within a few yards of each other near Ikushimbets, and the third from a nodule in

the river exposure of Mo-Yubari. The slides catalogued as 21 A 7 to 21 A 12 are cut transversely through an axis with a considerable amount of secondary wood and with several leaf bases attached. The slides 21 B 4 to 21 B 10 contain a series of oblique sections through an axis of about the same size as that in 21 A, to which are attached a number of leaves, the section also cutting other leaves which obviously belong to the same twig (see text-fig. 18). Slides 4 Z A 1 and 2 contain two small leaves cut transversely and one cut obliquely, but they are of special interest because their external appearance was seen before the sections were cut. The nodule had been split, and one surface showed the rough cross section of two diamond shaped leaves, and at the edge a minute fragment of a third, which was seen in surface view on the adjacent face, lying at right angles to the first. This block, as it was before cutting, is illustrated in fig. 11, Plate 1, where *s* is the first face, with *l* the two leaves in section and *L* the leaf seen on face *s* at right angles to *s*. Fortunately just sufficient of



TEXT-FIG. 18.—Oblique Section of the Axis of *Cryptomeriopsis*, with leaves attached and lying near it.

w., Wood of axis; *v.*, bundle of leaf; *g.*, central large duct of leaf; *g.*, the two lateral canals, one on each side of *g.*
x 5.

leaf *L* appeared in transverse section to prove its identity with the leaves *l* which are in turn identical with those in the other two blocks attached to the axes.

We have, therefore, from this plant: the stem in transverse and oblique sections, leaves attached to the stem cut in both transverse, oblique, and longitudinal

directions, as well as others cut from the middle and the tip of the leaf, and the external appearance of a leaf.

The twigs were thickly clothed with leaves which were attached directly to the axis by their broad bases. There is not enough evidence from the fossils to determine the phyllotaxis, but it must have been a high one, and the twigs must have had a brush-like appearance, externally like a small leaved *Araucaria*, *Cryptomeria Japonica*, or the newly described genus *Taiwania*. Its leaves are rather more massive at the base than those of these living plants.

The Axis.—The wood of the axis is about 1·5 mm. in diameter; the large size of the closely arranged leaf bases prevents an estimation of the true cortical extension. The secondary tissues are well developed, but there is no sign of an annual ring.

The tissues are fairly well but not perfectly preserved, owing partly to the ravages of a fungus whose hyphae are seen in many of the cells of the plant.

The *Pith* consists of homogeneous, roundish cells, closely packed so as to leave only small intercellular spaces (see Phot. 35, Plate 6). Some of the cells are filled with a clear brown mass which appears to have been of a resinous nature, while others are suggestive of thick-walled stone cells, not very favourably preserved.

The *Protoxylems* can be recognised in from eight to ten groups in each section. In those cut obliquely the narrow elements show spiral thickening. A whole protoxylem group moves outwards to supply the leaf.

The *Secondary Wood* consists of uniform elements of small diameter. There is no sign of an annual ring in either of the specimens. In oblique sections, large, round, bordered pits are clearly recognisable in single rows on the radial walls; the sections do not make it clear whether or not pits are also present on the tangential walls.

The *Medullary Rays* are broad in contact with the pith, and soon narrow down to a single row of cells. In oblique sections of the axis they can be seen in tangential section, and consist in most cases of a single row of cells, one cell high, though a few are two cells in height (see Phot. 36, Plate 6, which shows a tangential view of the wood from an obliquely cut section).

The medullary rays can also be seen in radial view, where in one or two places their pits are visible. These are round or slightly oval, lying a little obliquely. As the nature of the pitting on the medullary rays is a point on which some weight has been laid (see GOTTHAN, 1905) we compared those of the fossil with pits in the same position in *Cryptomeria*, and found them to be of the same type. The character of the wood and the tracheal pittings made it clear that there could be no close affinity between this fossil and *Araucaria*, though there was the external similarity of foliage. Hence we compared the details of the wood with those of *Cryptomeria* and *Taiwania*, to which there was also a close similarity. The comparison showed that in its axial characters the fossil came closer to *Cryptomeria* than to the other genus, though differing from it slightly, as will be mentioned later.

The *Cambium* zone is normal in position and structure, and can be recognised outside the wood in several places (see c, Phot. 37, Plate 6).

The *Phloem* lies outside the cambium and can be seen in parts of the stem which are well preserved, see Phot. 37, Plate 6. The radiating rows of secondary phloem elements consist of fairly large clear cells, presumably sieve tubes, though they cannot be identified exactly in the oblique sections, and others with contents some of which are of smaller size. Outside the secondary phloem on the same radius as the protoxylem group can be seen a number of more crushed elements which are presumably the protophloem. There appear to be no sclerised elements in the phloem, or directly outside it, nor are there resin ducts. The lack of sclerised cells in the zone of secondary phloem is a point in which the fossil differs from the living *Cryptomeria*, where there are frequent thick-walled cells alternating on the same radius with the sieve tubes and forming very definite concentric rings, and still more from *Taiwania*,* where even in very small twigs the secondary phloem zone is conspicuously large and the sclerised elements alternate with great regularity with the soft tissue. In the fossil one or two cells were observed which might have been thick walled, but they were of a doubtful nature, and in most cases the radii of phloem were clearly soft walled and rather less in extent than in corresponding twigs in the living genera.

Leaf Traces.—A group of protoxylem moves out through the secondary wood to supply each leaf. One can be seen in Phot. 35, l.t., Plate 6, on its way out. The trace enters the leaf undivided.

The Leaves.—The leaves were simple pointed structures, diamond shaped in cross section, as is seen on the diagrams in text-fig. 18, and Phot. 38, Plate 6, and were sessile, with no differentiation of a special base. The leaf base is almost as great as the whole diameter of the axis. The external appearance of the leaf, as is seen in fig. 11, Plate 1 (magnified by two diameters), is quite similar to that of a pressed specimen of *Cryptomeria*, *Taiwania*, or *Araucaria*. The shape of the leaf in transverse section is seen in text-fig. 18 and Phot. 38, Plate 6. There is considerable variety among the different leaf sections owing to the slightly varying directions in which the sections were cut, and also to the fact that at the base the leaves appear to have been more grooved (see Phot. 38), while they became more smoothly oval at the tip (see Phot. 39).

The *Epidermis* cells are, like those of normal Gymnosperms, small celled with thick outer walls.

The *Stomates* are particularly well preserved and numerous. In surface view they are seen in a number of leaves which are cut slightly obliquely. They are of the

* The anatomy of *Taiwania*, except for a few details of the leaf, is as yet undescribed. The kindness of Dr. HAYATA, its discoverer, put us in possession of some material, from which we cut sections for our comparison with the fossil. *Taiwania* (see HAYATA, 1907) belongs to the Taxodiinae, and comes near to *Cryptomeria* in several respects, and to *Cunninghamia* in others.

normal Gymnosperm type, slightly sunk (though less so than in *Pinus*) and with the guard cells placed at an angle (see PORSCH, 1905, where attention is drawn to the phylogenetic value of this character). In Phot. 38, Plate 6, slight indications of the stomates are to be seen at α in the photo. They lie, therefore, on each side of the leaf, a point which has a certain systematic importance. The number of stomates on the morphologically upper surface of the leaf, as determined by its anatomy, seems generally to exceed that on the lower side. This may be the result of the position of the leaf, which seems to have stood up, somewhat curved towards the axis; hence the upper side would have been slightly the more protected one. The section in Phot. 38, showing the stomates on the four sides, is from the basal portion of the leaf, while in those from the apical part (see Phot. 39) we have not observed any stomates on the lower side though they are to be seen on the upper surface. In this distribution of their stomates the fossil and the living *Cryptomeria* agree.

The *Hypoderm* is a fairly uniform single row of cells under the epidermis. They are well sclerised, and approximately circular in section. Naturally the layer is interrupted by the stomates. The ground tissue of the leaves is not quite so well preserved as we could wish. This is possibly due to the fungus already mentioned as infesting the stem, and which is found in nearly every leaf. Phot. 38, Plate 6, shows the general type of preservation of the assimilatory tissues. Isolated portions of leaves here and there prove that the outer cells were closely packed though the cells were hardly so elongated as in typical palisade tissue, while the inner tissue was loosely built of irregular elongated cells between which were large air spaces, as is also the case in the leaves of living *Cryptomeria* and *Araucaria*.

The *Resin Ducts*.—Throughout the length of the leaf nearly to its tip run three resin ducts. The central one is of large size (see G, Phot. 38, Plate 6), lying immediately beneath the single vascular strand, which sometimes curves to partly enclose it with its lateral wings of transfusion tissue. On either side of the central canal lie two lateral ducts of smaller size, g. of text-fig. 18 and Phot. 38, Plate 6, which constantly accompany the main duct until toward the tip of the leaf, when they die out, and leave only the single central resin duct as is seen at G, Phot. 39, Plate 6. In some sections, otherwise apparently transverse, the lateral ducts appear to be slightly elongated in section, but this is not a constant feature, and in many leaves they appear quite round.

In comparison with the living *Cryptomeria*, the central duct is larger and the lateral ones placed nearer to it. In the living genus, as in the fossil, the lateral ones often die out about midway up the leaf.

In the number and arrangement of its resin ducts the fossil agrees with *Cryptomeria*, and is unlike the other genera hitherto mentioned as being similar to it in other respects. The small-leaved Araucarias we examined had eight or nine ducts arranged round the leaf, while *Taiwania* has only one from base to tip, which is large and takes a central position. In the fossil in most cases the lining epithelium

of the duct is not preserved, but in Phot. 40, Plate 6, *e.*, this may be seen, though not in a perfect condition.

The *Vascular Bundle* runs simply up the leaf in a central position above the large resin duct, and without lateral division. Almost immediately on its entry into the leaf base it spreads laterally and forms a very narrow extended band of vascular tissue (see Phot. 40, *v.*, Plate 6). So far as we can ascertain, no secondary tissue is developed in the leaf, and the wood consists of a number of very small elements irregularly arranged and mixed with a few parenchyma cells. The strand gets smaller further up the leaf, and at the tip is reduced to a group of but two or three cells. The most noticeable feature of the bundle is the quantity of transfusion tissue which is constantly found on either side, see Phot. 40, Plate 6, *tr.* These cells are large and somewhat irregular in shape, and their markings vary from pitting to scalariform banding. An illustration of part of a mass of these tracheids is seen in oblique section, where their pitted walls can be clearly recognised (see Phot. 41, Plate 6). The elements lying laterally are large, and gradually get smaller as they approach the true wood of the bundle, with which they merge almost imperceptibly.

A definitely organised bundle sheath or endodermis is not recognisable, though, as can be seen in Phot. 38, Plate 6, there is, round the vascular strand, a more compactly arranged, roundish-celled tissue than that which forms the general mesophyll of the leaf.

We must now compare the bundle characters of this leaf with those of the other plants previously mentioned as being possible living allies. The small leaved *Araucaria* is unlike the fossil in having three separate small strands in each leaflet. This, combined with the essential difference in the tracheal pitting in the axis in the two plants and the number of resin ducts in the leaves, is sufficient to separate them definitely. *Cryptomeria* has a single strand running through the leaf. The vascular elements, however, are more definitely grouped in radial rows, and form an almost circular bundle, while the quantity of transfusion tissue in all the leaves we have examined is small, and not at all on the same scale as in the fossil. Thus with *Cryptomeria* the essentials are similar, *viz.*, a single small strand with transfusion tissue and an ill-defined bundle sheath, so that the fossil might well be an allied species. Though the shape of the leaf (the fossil "diamond" extended laterally, and the *Cryptomeria* diamond extended vertically as regards the vascular axis), the difference in the placing of the vascular elements, and the great difference in the quantity of transfusion tissue are sufficient to indicate that it might be that of a closely allied but distinct genus. We therefore turned to *Taiwania* (see footnote, p. 54). Dr. HAYATA (HAYATA, 1907) has described shortly the structure of the leaf, which in many points seemed, from his description, to come very close to the fossil (see his fig. 14, Plate 1). The sections of *Taiwania* which we ourselves cut, however, revealed a curious and interesting character of the leaf which had escaped Dr. HAYATA's notice. It is only towards the tip of the leaf that it has a single

bundle such as he describes. We found that three distinct strands enter the leaf base : first two, which place themselves one on each side laterally of the central large resin duct, and then at a slightly higher level a third comes out from the axis and places itself medianly above the duct. Later, the three fuse and form the single bundle which Dr. HAYATA describes. Hence we are left with *Cryptomeria* among living plants as the nearest parallel to the fossil, though they do not coincide absolutely.

As the twigs are but one year old it is impossible to be certain whether the whole tree bore only such leaves. It might have been the case that in the older branches leaves of two types, or even dwarf shoots, developed. Judging, however, from the close similarity in the axis and the essential features of the leaves of the fossil with *Cryptomeria*, it does not seem likely that there was any but the type of foliage borne on the twigs we have. The decurrent base of the leaf seems to suggest that the leaves were not deciduous, and as a consequence effete twigs fell off with their leaves attached as in *Cryptomeria*, *Taxodium*, and other genera now living.

Affinity.—Notwithstanding the similarity of this fossil to *Cryptomeria*, we do not forget the fact that no final decision can be reached from stems and leaves alone. The leaves are not identical with those of *Cryptomeria*, in the shape of both leaf and vascular bundle, and in the large quantity of transmutation tissue, the fossil differs from *Cryptomeria*, while in the living plant the lateral resin ducts die out more rapidly than they do in the fossil, while the axis, though very similar, differs in the fossil, having no development of stone cells in the phloem. Hence there is enough to justify a suspicion that the fossil might prove to have fructifications which would necessitate its removal to another genus. But until that proves to be the case the vegetative similarity between the fossil and *Cryptomeria* is such that we cannot do other than associate the two closely. Hence the name *Cryptomeriopsis*.

Diagnosis:—

CRYPTOMERIOPSIS, gen. nov.

General external appearance like *Cryptomeria*. The leaves diamond shaped in section. In each leaf there is a single vascular bundle above a large central resin duct and two lateral resin ducts. Stomates on both sides of the leaf. The axis as in *Cryptomeria*. Tracheid with a single row of round bordered pits. Wood without tannin cells, cortex with resin ducts.

CRYPTOMERIOPSIS ANTIQUA, sp. nov.

Leaf slightly larger than *Cryptomeria*, diamond shape in section laterally extended. Vascular bundle much extended laterally, quantity of transmutation tissue very large. The lateral resin ducts dying out soon. In the axis the phloem is without stone cells.

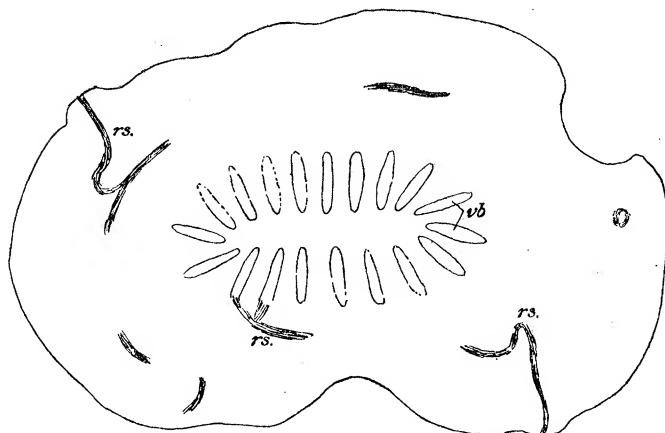
Upper Cretaceous, Hokkaido, Japan.

VOL. CCI.—B. 274.

*Sauruopsis niponensis.**

(Text-fig. 19; Photos. 42-47, Plate 7.)

The single specimen we have of this plant lies in sections 1 B 1-1 B 10, cut in transverse direction, and in slide 1 B 11-1 B 13 in oblique longitudinal direction. This consists of the axis, which is giving off numerous rootlets (in every section there



TEXT-FIG. 19.—Diagram of the Stem of *Sauruopsis*, showing its irregular outline, the central ring of vascular bundles, *v.b.*, and the irregular strands, *rs.*, going out to the roots. $\times 15$.

are several in the course of exit from the axis), and which seems to have been either a rhizome or the base of a stem. It is slightly flattened in the sections, but this seems to be due, partly at least, to crushing. The size of the stem varies considerably in the different sections, the larger diameter being about 13 mm. The outline of the transverse section is extraordinarily irregular (see text-fig. 19, which gives a plan of the tissue arrangements), which seems to be due partly to the

bases of the numerous appendages and partly to possible wounding, but at the same time it looks as though the actual specimen had been knotty and irregular, as is

* The identification of fossil Angiosperms by means of their vegetative anatomy is a subject which is at present in its infancy. Hence there is an inevitable tendency for anyone forced to attempt to identify fossil fragments from their anatomy to rely on local information. To escape this danger so far as possible, we sought out the available data from the scattered literature on Dicotyledonous anatomy, with the object of making a general key. The only comprehensive book on the subject of the anatomy of Dicotyledons (namely that of SOLEREDE) has no tables, keys, or plans by which it is possible to run down an unknown plant by its anatomy alone, but the chapters merely recapitulate the details of family after family of the natural orders. The few works which include any account of fossil Dicotyledons give no help for a general key.

We saw, therefore, no alternative but to attempt the construction for ourselves of the lacking key before beginning the work of identifying our fossils. For this purpose we abstracted the necessary details from SOLEREDE's monumental work, and the supplement to this in the English edition (SOLEREDE, 1908), as well as all the available additional details from papers by a number of authors. For the purposes of the key, only the more reliable and essential data were selected and tabulated in columns. For the plants which he describes most of these details were available in SOLEREDE's work, with one rather notable exception, namely the omission of the medullary rays; the vertical height which, though of great systematic importance, is hardly ever mentioned in his book.

The tables we compiled we found extremely useful for the preliminary determination of a specimen, for by this means we could feel sure that every known family had been considered to some extent, while the large majority of them we could at once eliminate from the list of those we had to examine in detail.

not infrequent with underground stems. The whole outline is enclosed by a delicate cork tissue, which is a dozen or more cells deep.

The appendages appear to be all of one sort, and as several of them show clearly that they were roots, it seems almost certain that all were of the same nature. There is no evidence of scales or leaves either attached or appearing to belong to the stems in any of the sections.

Main Axis.—That portion of the main axis which we have is a little more than 2 cm. long, and roughly 13 mm. by 8 mm. in diameter, though very irregular. Its tissues, except for the wood of the vascular bundles, are entirely soft walled, there being no evidence of any form of strengthening tissue. The separate vascular bundles are placed in a ring towards the middle of the stem (*cf.* Phot. 42, Plate 7), but this is broken or crushed in all the sections. In addition to these bundles there is a number of strands running in a variety of directions in the cortex to supply the appendages.

The cork layers surrounding the irregular outline of the stem, are thin walled in regular radial series, and bend up round the base of the appendages. There are numerous cells in the pith and cortex which are infested with fungi (see p. 4), but, as well as these, there are cells which seem to be of a secretory nature, and are recognisably different from the former, which are noteworthy because they seem to correspond to the "oil cells" characteristic of the living family in which we place this fossil.

To describe the tissues in detail :—

The *Cortex* consists of practically uniform soft-walled cells, roughly circular in outline (averaging 0·05 mm. in diameter), and fitting together so as to leave practically no intercellular spaces. Mixed together with these cells, are some with thicker brown walls and opaque contents, which are much the same size as the rest of the cortex, although more irregular and sometimes rather elongated. As in the case of the corresponding cells in the living members of the *Saururaceæ*, their cell walls may have been suberised. The cork layers outside the cortex show no evidence as to the seat of their origin, which was, however, superficial, because there is a broad zone of cortex outside the vascular bundles, so that it could not have lain deep in the cortical tissue or in the pericycle. The cork cambium is not sharply distinct, but seems to lie toward the base of the dozen or so cells in a radial row in the zone of secondary tissues ; the cells cut off from this on its inner side, forming normal phellogen. The cork layers do not appear to have been heavily suberised and contain no thick-walled stone cells in their layers.

The *Vascular Bundles* form a single, normally orientated ring towards the centre of the section. They appear to have numbered about sixteen, but in no section is the ring entirely complete, as the bundles are anastomosing, or crushed, or the stem is broken in every section. The arrangement and relative size of the bundles are shown in text-fig. 19 in diagrammatic form. As well as these bundles, there is a large

number of strands coming from them and running in the cortex in every direction, some, as in text-fig. 19, *r.s.*, running tangentially to the axis and giving off strands to the appendages. The bundles have no definite sheath, either of sclerised, or of specialised soft cells. An endodermis is not recognisable, though it was very probably present. Thus the pith is not visibly separated from the cortex, and is entirely like it in composition. The medullary rays are several cells broad and are quite unspecialised, and like the ground tissue.

The wood is particularly remarkable in consisting of elements which are entirely scalariform, except for a few spiral protoxylems. The protoxylems lie in the normal position on the inner side of each strand, and can be seen in oblique sections to consist of narrow, spirally thickened elements. They are well seen in a number of the longitudinally cut strands of the appendages. The metaxylem consists of wood elements mixed with a very small quantity of parenchyma. In transverse section these elements appear very homogeneous in size, there being no distinction between large-lumened vessels and small tracheids and fibres as is so usual in Angiosperms, but the wood cells are much of a size. They measure from about 0·02 mm. to 0·04 mm. in diameter. This uniformity in composition is seen in Phot. 43, Plate 7.

In longitudinal and in oblique sections the thickening of their walls is very readily seen, and appears to be entirely and exclusively scalariform, generally with a single row of much elongated pits on each facet of the wall. These are shown in Phot. 44, Plate 7.

There is no evidence of a normal cambium, although in the last section, where the stem seems to have been much damaged prior to fossilisation, there is a cambium-like zone round the bundles which extends somewhat down each side.

The *Phloem* in nearly all cases is either oblique or too ill preserved to be treated of in any detail. In the last section, mentioned above as having been wounded, one of the bundles shows the small-celled tissue outside the xylem in transverse section, but it is not free from suspicion that it has been affected by the wounding. The cells are small, squarish, and apparently thin walled, with no very clear differentiation, but they look much like a tissue consisting of squarish sieve tubes and parenchyma (see Phot. 45, Plate 7). Outside them lies a group of thicker-walled cells with clear brown contents, which seem to be secretory cells. They are seen to accompany the vascular bundles in all the sections. A few of these cells pass out with the strands running to the appendages, and can be recognised in both transverse and longitudinal sections of the bundles. There seem to be no sclerised elements among or outside the phloem.

Pericycle and endodermis are not recognisable. The latter, however, was most likely present, judging from analogy with the living plants which these fossils otherwise so much resemble.

Appendage strands running out through the cortex follow a variety of directions. Their origin is not very definite: sometimes they are clearly seen to arise from the joined strands arising from two axial bundles, sometimes from part of one, and some-

times as branches given off in the cortex from another, appendage strand. In this they agree with the rootlets given off from the base of the stem of the living *Saururus*. The course of these bundles is also very erratic : in many cases they run straight out to the appendage, while in others they may run round outside the vascular bundles in a tangential direction for some distance, and then give off a side branch to a root. In these details also there is entire agreement with the living family. Some of the bundles in the fossil curve very much, and may even bend back suddenly in a **U**-form, or may go in a direction like an **S** to the exit (see Phot. 46). The strands consist, like the main bundles, of scalariform elements, among which it is usual to recognise in an oblique section one or more spiral protoxylems. In all cases the bundles are accompanied by several cells of a secretory nature, like those in the phloem region of the main bundles.

The Rootlets.—The broad base of attachment of the rootlets is seen in sections of the stem (see Phot. 46, Plate 7) ; the xylem strand lies in the middle of the pad, sometimes projecting even a little further into the matrix than does the soft tissue. Only one detached rootlet is seen near the main axis, and this is cut in transverse section, and is like those still embedded in the cortex. Round the rootlets in the cortex near their point of exit is a sheath of cells separating them from the cortex in which they lie. Most of these strands are cut, naturally, in oblique and longitudinal directions, though a few are seen transversely.

In one such case (see Phot. 47, Plate 7), the rootlet seems to have no metaxylem differentiated, but there are four, perhaps five, groups of protoxylem elements much as appears in the living family. In the pith of the rootlets are a few of the brown secretory cells, of which there are also a number outside the wood elements.

Habit.—From the anatomy of the large axis there appears to be no question but that it is of stem nature. The fact, however, that its only appendages are roots, and that there are so many of them, strongly suggests that it was a rhizome, or at least the basal portion of a stem. The complete absence of any bands or wedges of sclerenchyma, or any form of strengthening tissue, supports the idea of a rhizome, as does the placing of the vascular bundles towards the centre of an undifferentiated cortex, and the walled uninterrupted cork layer.

Saururus, with which the fossil has many points of likeness, has aerenchyma tissue, which it retains to some extent even when not growing in its natural habitat, a swamp. There is no such tissue in the fossil, which has a fairly compact cortical tissue, like *Houttuynia*, and was, as a consequence, probably growing on ordinary soil.

The fossil may be imagined as a fairly thick stem or rhizome, with a corky covering, an irregular knotty appearance, and with many attached small rootlets growing out all over it.

Affinities.—Although from the anatomy of stem and rootlets alone it is a matter of extreme difficulty and some uncertainty to determine the affinity of an Angiosperm, in this case there are several anatomical peculiarities which are so well marked and

unusual that we feel less hesitation than might otherwise be the case in assigning the plant to the *Saururaceæ*. Besides the minor points of agreement, there are the following:—The entirely and exclusively scalariform thickenings of all the wood elements except the protoxylems and the form of the ladder-like bars; the uniformity in size of the wood elements, which are not mixed with large vessels as is usual in Angiosperms; the grouping of the wood elements with little parenchyma and no fibres; the presence in pith and cortex, and accompanying the outgoing rootlets, of large numbers of some sort of secretory cells. Further, in the manner of the exit of the rootlets, whose vascular strands may partly circle the stem before going out, and in the structure of the rootlets, the fossil agrees with the *Saururaceæ*. With this primitive family, then, we include the fossil for the present, calling it *Saururopsis*. It seems to differ somewhat from all the three living genera, but partakes to some extent of the nature of each:

Without fructifications we cannot throw any light on the evolution of the group, but it is of interest to find that this very primitive family, placed by ENGLER first among the Archichlamydeæ, with its four species confined to Eastern Asia and America, was represented in the Cretaceous flora of Japan.

Diagnosis:—

SAURUROPSIS NIPONENSIS, gen. et sp. nov.

Underground stem, 2 cm. in diameter, with very numerous rootlets attached. Vascular bundles of the axis in a ring. Each bundle composed of uniform wood elements about 0·02–0·04 mm. in diameter, all simply scalariform. Secretory cells beside the phloem, and accompanying and contained in the rootlets. Vascular strands passing off to the rootlets in a very irregular course in the cortex.

Upper Cretaceous, Hokkaido, Japan.

Jugloxyylon Hamaoanum.

(Phot. 48, Plate 7.)

This species is only known to us from its secondary wood. Hence we will merely mention it at present and reserve its fuller description till more specimens come under observation.

The salient features of the wood are:—The narrow medullary rays, most of which are one or two cells broad; the large size of the widely scattered vessels, which are relatively few in number compared with most woods; and the character and arrangement of the wood fibres. The vessels are round in section, and vary from 0·06 to 0·12 mm. in diameter, the average size of the summer wood vessels being 1 mm. They are isolated and placed at a considerable distance from each other, or adjacent in pairs, while in a few cases there are groups of three or rarely four in a radial direction, particularly in the neighbourhood of the limit between two annual rings. The wood fibres appear to be rather thin walled. They measure about

0·02 to 0·03 mm. in diameter, and are arranged with considerable regularity. The medullary rays are numerous, arranged so as to separate practically every series of vessels on a radius. They are principally one cell broad, but not infrequently two cells.

Affinities.—The relatively large size of the vessels in a wood with such narrow rays is a feature which serves to separate the wood from the majority of species. The proportion of Angiospermic woods with medullary rays only one or two cells broad, after the first or second year of growth, is not very great. The living *Juglans*, however, in the species we examined, unites the characters of narrow rays and large, thinly scattered vessels, and very closely resembles the fossil. The name *Jugloxyylon* is therefore given as descriptive of the appearance of the wood, although we lay no particular stress on the systematic position that the name suggests.

The species name is given in honour of Baron HAMAO, the President of the Imperial University of Tokio.

Diagnosis:—

JUGLOXYLON HAMAOANUM, gen. et sp. nov.

In the secondary wood the vessels are placed at wide intervals. They are 0·06–0·12 mm. in diameter, averaging 1 mm., and are circular in outline. Wood fibres thin walled, regularly placed. Medullary rays mostly one cell, though not infrequently two cells in breadth.

Upper Cretaceous, Hokkaido, Japan.

Populocaulis yezoensis.

(Phot. 49, Plate 8.)

This plant is represented by two twigs lying in the same nodule, but not attached to each other. The smaller is about 5 mm. in diameter, and cut in transverse section.

The stems, as a whole, have no very salient feature beyond the medullary rays, which are only one cell broad, but are much more sharply preserved than the rest of the tissues, and show up their thickened and pitted walls clearly against what now appears as a thin-walled ground mass of wood. There are no leaves or branching visible in the stems, so that the affinities of the plant are consequently difficult to diagnose, and we do not propose to describe them fully here.

The *Pith* is only recognisable in the smaller sections, and is somewhat star-shaped, with five rays.

The *Vessels* are scattered fairly evenly through the secondary wood. They are generally isolated in the ground tissue, but sometimes lie so that two or even three are adjacent. Their size varies from 0·04 to 0·08 mm. in diameter, but most are about 0·06 mm. in diameter.

The *Medullary Rays* are nearly all one cell broad. Many of them seem to be only two or three cells, but a few are four or six cells in height, though as there are no tangential sections their height is not certainly determinable. The individual cells of the ray are usually squarish in outline, but some are slightly elongated in the radial direction. Their walls are the most noticeable feature of the plant, and are thick and pitted, and thus show up very strikingly against the apparently thin-walled mass of the wood.

The living group with which these stems seem to agree more closely than with any other, so far as we can ascertain, is the genus *Populus*.

Diagnosis :—

POPULOCaulis, gen. nov.

Stems with secondary wood. Wood with round vessels, scattered vessels with numerous roundish pits. Medullary rays mainly one cell broad, their cells uniform, rectangular, thick walled, with many small pits. Groups of thick-walled fibres in the phloem.

P. Yezoensis, sp. nov.

In stems about 7 mm. in diameter the wood vessels average about 0·06 mm. in diameter. Wood fibres rather thin walled, 0·02–0·03 mm. in diameter. Pith five rayed, with five main groups of primary wood. Cork arising deep in the cortex.

Upper Cretaceous, Hokkaido, Japan.

Fagoxylon hokkaidense.

(Phot. 50–53, Plate 8.)

The specimen of this plant, which is unfortunately very fragmentary, lay in a nodule of large size in which there were no other plant tissues, beyond disintegrated scraps. The extent of the tissue of this specimen indicates that the original woody stem must have been of large size. The only tissues present are those of the secondary wood traversed by broad medullary rays. Of these tissues we have transverse, radial, tangential, and oblique sections (slides 4 B 9–4 B 1), and where the cells are preserved at all they are preserved excellently, the pitting on the wood fibres being remarkably beautiful. There is no sign of annual rings, which must consequently have been broad, as there is a fair extent of tissue preserved in a radial direction. The wood is chiefly remarkable for the number and the width of its medullary rays, some of which reach the size of 18 to 20 cells in width.

The Wood.—In the fragments preserved, the wood is uniformly developed, with numerous large vessels scattered in the matrix of small thick-walled fibres. The vessels are usually separated from each other, but in a few cases two lie adjacent, in which position they are generally placed laterally and not radially. The general disposal of the vessels is seen in Phot. 50, Plate 8. They average about 0·08 mm.

in diameter, varying from 0·06 to 1·0 mm., and are approximately circular. In longitudinal views a number of the vessels show scalariform thickening, with the bands far apart, and usually stretching entirely across one facet of the wall. In a few places indications can also be seen of simple round pits of small size in the thick walls, or of slightly elongated pits.

The mass of tissue between the vessels consists of uniform small-celled wood fibres, about 0·01 to 0·02 mm. in diameter, with small lumina, and very clearly preserved pit canals in the thick walls. These are seen in Phot. 51, Plate 8, and in a very high magnification in Phot. 54, Plate 10. Among these thick-walled cells are some with thinner walls, of which the lumina are often filled with blackened or brownish contents, similar to the filling of many of the medullary ray cells, and which therefore probably represent parenchyma cells among the wood fibres.

In longitudinal section the pittings of the fibres are also excellently preserved, and are seen to have a definite round border with a slit-like opening.

The *Medullary Rays* vary considerably in breadth, and usually about five narrow ones lie between the broad ones. The relative sizes of these are seen in the following list of numbers, which gives the number of cells in width of a series of consecutive medullary rays : 14, 2, 3, 5, 3, 3, 18, 2, 3, 3, 3, 3, 13, 6, 1, 2, 3, 2, 3, 2, 3, 15. Some of the broad rays are as much as 20 cells in width.

In transverse sections the cells composing the ray are elongated radially, and measure from about 0·05 × 1·0 to 0·02 × 1·4. In many cases their tangential walls are not rectangular in the usual way, but slope very considerably (see Phot. 51, Plate 8). The ray cells have slightly thicker walls with visible round pits, so that the transverse section of a group of ray cells much resembles the longitudinal section of short thin-walled prosenchyma.

In most of the cells are blackened or brownish masses, or reticula of very various appearance in the different cells, but presumably the remains of the protoplasmic contents.

In longitudinal tangential section the rays are seen to be very high as well as massive (Phot. 53, Plate 8), over 90 cells in vertical direction being counted in medium sized rays. Larger ones were incomplete in the section, but showed 150 cells in vertical direction. The individual cells are roundish, slightly lenticular, and fitting into each other irregularly, but giving an appearance of horizontal stratification. In radial section the cells appear rectangular, elongated horizontally, and closely fitted, most of them show slightly thickened walls pierced by fine pit canals which are often bifurcated.

Affinities.—Having only the secondary wood and medullary rays to judge from, we cannot speak decisively as regards the affinities of the plant, but the agreement between its wood and that of a large stem of the living genus *Fagus* is such that it suggests, if not necessitates, the inclusion of the fossil in the group *Eu-Fagus*. As SOLEREIDER points out, the characters of this section of Fagaceæ differ with constancy

from those of the *Noto-Fagus* series, and it is in the former that we find the closest likeness to the fossil. In the living examples of *Fagus* which we examined, the diameter of the vessel averages a trifle less than those in the fossil, but in their scattered, equally distributed placing, and in having but slightly marked annual rings, the living and fossil forms agree. Further points of agreement are found in the prevalence of scalariform banding in the vessels, the round bordered pits with slit-like openings in the wood fibres, the broad medullary rays alternating with narrow ones, and in the shape and height of the tangential view of the principal rays. We have consequently named the fossil wood *Fagoxylon*, on the same grounds as the various Gymnospermic -*oxylons* have been named.

The genus *Fegonium* of UNGER and FELIX, with which this plant has, presumably, some relationship, is of Tertiary age, and does not seem to agree entirely with our fossil.

Fagoxylon must of course have general affinities with the whole Cupuliferæ, but the woods of *Quercus* and *Passania* (which are of the broad rayed type) which we examined are sufficiently different to separate it from them, while the rest of the Cupuliferæ seem to have narrow rays in the wood. The relation to *Fagus* itself, judging from the similarity of the two woods, may prove to be a very close one, but until more of the plant is known this cannot be determined.

Diagnosis :—

FAGOXYLON HOKKAIDENSE, n. foss. nov.

Secondary wood closely similar to that of the living *Fagus*.

F. HOKKAIDENSE, sp. nov.

Vessels in the wood lying singly, a few in pairs. Vessels averaging 0·08 mm. in diameter. Scalariform thickening and round or slightly elongated pits. Medullary rays very broad, up to 20 cells in width; also very high, up to 150 cells or more in height; wood fibres thick walled, with many pit canals, and slightly bordered pits.

Upper Cretaceous, Hokkaido, Japan.

Sabiocaulis Sakuraii.

(Phot. 54, Plate 8, and 55, 56, and 57, Plate 9).

This species appears to be the commonest of the Angiosperms of this fossil flora. There are a number of small fragments of it in various blocks, and five fairly well preserved stems of different sizes among the specimens. Unfortunately, there are no branches attached to the large twigs nor any leaves or other parts. We have, therefore, merely vegetative twigs, some with no secondary growth, and some in which there is a considerable zone of secondary wood. The minute twiglets, of which there are two in one of the blocks with the larger stem, may possibly have been petioles, as their shape is rather bilateral than circularly symmetrical, but there is no proof that they are other than thin twigs.

The principal specimens are : The minute twigs in slides 4 Q 24B and 4 Q 32A-35A ; the stem with a little secondary growth in the latter sections, and another in 1 V 2-4 and 1 V 1 2-5, and the largest stem in K.F. 7B Y 1-11. There is no perfect stem among them, though parts of each specimen are well preserved.

The general appearance of the transverse section of the average stem, with its noticeably large patches of bast fibres, is seen in Phot. 54, Plate 8. Section 56, Plate 9, shows the minute unthickened twiglets. In the older stem the most noteworthy character is the sclerised masses of the medullary rays outside the wood, which unite the bast fibres and form together a complete sclerised ring round the stem.

The smallest twiglet, the possible petiole, has a diameter of 1 mm., and the largest stem of 6 mm. The latter specimen, unfortunately, lies at the edge of the matrix so that it is not complete in any section, as is also the case in the medium sized stem (4 mm. in diameter) which, except in two sections, lies so that only a rim of its tissue is preserved in the matrix. The details of the stem agree fairly well in all the specimens, though a few minor points are uncertain owing to the differences in the types of petrification in different nodules.

The Pith.—This consists of two fairly distinct though not abruptly delimitated regions. The central part is composed of roundish and hexagonal cells, fitting so as to leave very small intercellular spaces. These cells are about 0·05 to 0·08 mm. in diameter, and have fairly thin walls in the smaller stems, in the larger stems a few of the cells are slightly thick walled and pitted. In the largest stem there are groups of stone cells, which are seen in the longitudinal sections to be rather irregular. Similar groups of cells were observed in the living genus which seems to come nearest to the fossil.

The outer zone of the pith consists of much smaller cells, among which are thick walled fibre-like cells forming a medullary cap on the inner side of the primary bundles. In the seam in 4 Q 32A the group of pith cells on the pith side of the bundle is as well defined and as large as is the phloem cap, though this is not always the case.

The Protoxylems are not absolutely determinable in transverse section, though the primary bundles are very clear, as is seen in Phot. 54, Plate 8. In longitudinal sections the protoxylem elements are seen as narrow vessels with spiral bandings. Near them are wider elements with scalariform thickening, presumably the rest of the primary wood.

The secondary wood, which has begun to form in the medium sized stems, forms a fairly wide zone in the largest, and remains entirely fascicular, the bundles remaining separated by the continuations of the broad primary medullary rays, with no formation of secondary wood between them. The vessels are circular in diameter, measuring about 0·04 mm. in diameter in the younger portions, which alone are well preserved. They are fairly numerous, and are placed singly among the wood

fibres. Among the secondary wood appear a few rather narrow elements with scalariform thickening, but the nature of the pitting of the larger vessels is uncertain, as they are not well preserved.

The wood fibres appear not to have been very thick walled, but are poorly preserved in the older sections. In the younger stem they are seen to be principally square in shape, of a diameter about 0·015 mm., and arranged in regular radial rows.

The *Phloem* is not perfectly preserved in any section. The brown crushed mass which represents it is, however, recognisable in all, and frequently shows something of cell structure (see Phot. 55, Plate 9, *ph.*), while the cap of hard bast is universally well petrified. The soft tissues of the phloem do not reveal any definitely organised sieve tubes or companion cells, but this is probably due to the bad preservation. The cap of fibres is deeply crescent shaped, half encircling the soft bast (see Phot. 54, Plate 8, *hb.*). It is composed of closely fitting cells, generally of from 0·02 to 0·04 mm. in diameter, but varying considerably. The walls are sometimes extremely thick, and often show the pit canals very clearly. In the oldest stem these caps of fibres persist, but only soft tissue seems to be formed in the secondary phloem, as is the case in stems of corresponding size of the living genus with which this appears to be allied.

The *Medullary Rays* of the primary stem persist uninterrupted by secondary interfascicular wood. They are fairly broad, consisting of about 6–10 cells. In some of the bundles of the oldest stem there are also secondary rays, two or three cells broad, which develop in the middle of the secondary wood. In transverse section the ray cells are small, 0·01–0·02 mm. in diameter, roughly rectangular in shape, and some, but not all, rather elongated radially.

In longitudinal section the secondary rays are few, but some seem to be fairly high, consisting of over 20 cells in vertical direction, some of the walls appearing rather thickened.

The most noticeable feature of the rays, however, is the very thick walled tissue of which they consist directly they leave the wood (see Phot. 57, *msc.*, Plate 9). This mass of stone cells joining with the hard bast fibres on either side forms a continuous though composite sclerised zone round the stem. This is also the case in the living *Sabia*, with which the fossil has many points in common.

The Cortex and Epidermis.—The cortical zone, even in the youngest stem, is not extensive, consisting of only about half a dozen to a dozen cells in width. There are no specially differentiated tissues, the cells being of much the size and appearance of the pith cells, with among them a few isolated stone cells with thick pitted walls.

The cork, of which there are two or three cell rows in the medium sized stem, appears to have been sub-epidermal, for cells which look very like the epidermis are recognisable in several places outside it.

In the smallest twiglets the epidermis is perfect (cork not having begun to form), and consists of small squarish cells in transverse section.

The Habit.—From so little evidence we can form no complete idea of the plant. Though there are 11 consecutive sections of one of the stems, there is no sign of leaves or twigs attached, so that the internodes were probably not less than 2 cm. long. The arrangement of the tissues of the bast, and the broad medullary rays keeping the primary bundles always distinct, favours rather than otherwise the view that the plant was a sprawler or unspecialised climber, possibly not unlike the Japanese sprawler *Sabia*, with which there are many points of similarity in structure.

Affinities.—The sclerised masses of the medullary rays joining the large cap of the bast fibres is a character, so far as we can ascertain, which is rare in the anatomy of Angiosperms. This feature, combined with the broad uninterrupted primary rays, seemed to limit the possible families in which to place the fossil, to the *Sabiaceæ* or the *Menispermaceæ*. The latter family, however, does not seem so similar to the fossil as the former, at least in the species we examined; for the vessels were very much larger and more irregularly placed in groups, the cap of the bast fibres was less developed, and the sclerised part of the medullary rays represented only by a few irregular and more or less isolated cells in the soft tissues of the outer part of the ray.

With the *Sabiaceæ* the likeness to the fossil is very marked. The anatomy of this group is but little known (SOLEREDE, 1908, p. 243), noting, however, the marked differences between the genera *Sabia* and *Meliosma*. It is with the species *Sabia japonica* that the fossil agrees. *Meliosma* differs considerably from the fossil, and lacks the sclerised ring composed of the hard bast patches and the sclerised outer parts of the rays.

Sections were cut of *Sabia* of various ages, corresponding to the fossil stems, and they all agreed very closely. The only two points of difference of any importance between the fossil and the living plants were found in the pith and the older wood vessels. There seemed no evidence that the fossil pith contained anything corresponding to the numerous secretory cells in the pith of the living plant, while the size of the vessels formed after the first year's growth seemed rather greater than those of the fossil. The latter point may depend on the fact that the outer part of the wood of the fossil stem was crushed and poorly preserved, so that the measurements of the vessels had to be taken from the inner half of the secondary wood, and were therefore probably less in size than those in the more external portions. As the likeness between the stems is so complete in the important features, there is no need to recapitulate all the details in which the fossil and the living *Sabia* agree.

The anatomical peculiarities of the *Sabiaceæ* seem to be so much better marked than those of most of the Angiospermic families that there seems to be a reasonable likelihood that the fossil belongs to the group, even though we have only the anatomy of the stem to go by, which is so insufficient in most cases.

The similarity between the living plant and the fossil is indicated by the generic

name *Sabiocaulis*. The specific name *Sakuraii* is given in honour of the Director of the Science College of the Imperial University, Tokio.

Diagnosis :—

SABIOCaulIS, gen. nov.

The anatomy of the stem very similar to that of the living genus *Sabia*.

SABIOCaulIS SAKURAI, sp. nov.

In stems up to 6 cm. in diameter, the arrangement is normal. The primary bundles are separated by broad primary rays, which are continuous without interruption through the secondary wood. Vessels 0·04 mm. in diameter in the first year wood, the smaller ones scalariform. A well-marked, crescent-shaped cap of sclerenchyma lies outside the soft bast, and is united to the outer sclerised part of the medullary rays to form a composite ring. There are no sclerised elements in the secondary bast. Pith with two zones, the bundles with a sclerised medullary cap. The cortex undifferentiated, with few stone cells. Phellogen apparently sub-epidermal.

Upper Cretaceous, Hokkaido, Japan.

Cretovarium japonicum.

(Photos. 58, 59, and 60, Plate 9.)

The only Angiospermic fructification which we have yet found among the fragments of this Cretaceous flora appears to have been fairly plentiful, for in three nodules we have seven distinct specimens.

The sections described are principally from block 1 YA, which has parts of five distinct specimens. Among them are two specimens in which there is preserved round the ovary some portion of foliar structure which may be a scale, but is more likely to be a perianth, as it is attached to two carpels in one of the ovaries.

It is unfortunate that none of the individual specimens are cut in more than one section, but this fact assists in determining their size, for it indicates that they must be not more than 3 mm. in vertical height or they would appear in a second section in the series containing transverse ones of the ovary. The sections are all transverse or transverse-oblique, no longitudinal section has been recognised.

The ovary is trilocular, the three loculi being of the same size; they are united in the centre with axile placentation. The diameter of the whole is about 2 mm. and presumably the vertical height is not much greater. As is seen in Phot. 58, Plate 9, the carpels are rounded off where not in contact, and the whole ovary was presumably globular.

Wall of Ovary.—As preserved in most of the sections, the wall of the ovary is not massive, consisting of a zone of three or four well-preserved cells with a streak of crushed tissue outside them. This outer zone shows signs of having been a soft fleshy layer outside the inner persistent one, but is too poorly preserved to describe.

The inner zone consists entirely of very thick walled elongated fibres which run partly horizontally and partly vertically in the wall. In all the sections these cells have much thickened walls, which seems to point to the fact that the ovaries were all approaching maturity.

In one of the sections the solid centre of the ovary is well preserved and shows a triradiate mark where the carpels join. This axile portion consists of small cells with much thinner walls than the rest; among them can be recognised the vascular strands.

Outside the ovary wall in slide 1 YA, lying in the angle between the junction of two carpels, is a roundish mass of cells, continuous with the tissue of the soft outer zone of the ovary wall. This is seen in Phot. 58, Plate 9, and may possibly be some sort of nectary or gland, though it may very well be merely a portion of the wall crushed upwards and cut tangentially.

There is no indication of true dehiscence of the ovary wall, or of any external features such as spines or hairs.

Vascular System.—Owing to the crushing of the outer part of the ovary, it is not possible to estimate the number, or even to be sure of the existence of strands in that region, though it is likely that some vascular bundles ran in the carpel walls.

In the axile part, as noted above, small strands of vascular tissue are preserved clearly in one section, though they are not recognisable in the others. There are two small groups of vascular tissue in each of the three portions of the column, making six central strands in all, corresponding to the rows of ovules. There seem to be only two or three very small tracheids (0·005–0·998 mm.) in each, surrounded by a cluster of thin-walled cells smaller than the rest of the ground tissue but not sharply differentiated from it. In their appearance these strands resemble those of the smaller Liliaceous ovaries very closely.

Placentation.—Only in one section is there any sign of the actual attachment of the ovules. This is in slide 3 YA where, as seen in Phot. 60, Plate 9, two points of attachment are clearly seen in each carpel, apparently at about the same horizontal level, so that it appears that the ovules were in two rows along the axile placentation.

Unfortunately of the ovules themselves no tissue remains. A brownish mass, like a crumpled membrane, in some of the carpels may possibly be interpreted as the coat of an ovule.

Foliar Structure presumably Perianth.—The attachment of the foliar structures to the carpels in slide 1 YA establishes the fact that they belong to the carpels we have just described, a fact which their relative position in slide 1 YA (seen in Phot. 58 and 59) would leave little room to doubt. In these two slides only are any such tissues preserved.

Whether the foliar structure represents a single bract or part of the fused tube of a perianth, it is impossible to determine absolutely from these specimens, but in its anatomy, so far as it is preserved, there is no indication of compound origin.

The lamina was thick, indications of not less than a dozen cells can be seen in places. The tissues, however, are too crushed and poorly preserved to make it possible to give any detailed description of them. In one or two places are oblique strands which suggest vascular bundles or strands of sclerenchymatous tissue. Just near the point of attachment of the carpels is a group of sclerenchymatous cells cut across so as to show the pit canals clearly in some of the thickened walls. There are also zones of thin-walled whitish cells which are highly suggestive of cork layers. The lamina, therefore, was evidently not of an entirely temporary nature, but persisted with the growing carpels.

In one of the slides is a suggestion of a second member of the same nature, but though the scrap of tissue lies where one would expect a second perianth member to lie, there is no organic continuity, and the scrap is too poorly preserved to indicate whether it belongs to the flower or is a stray fragment in the matrix. This is seen in Phot. 58, Plate 9, at *p*.

Attachment of Carpels to Foliar Structure or Perianth.—This is seen in the only case we have at present, in Phot. 59, Plate 9, where two carpels are attached to the foliar organ. The small space between them, *s.*, may possibly have been a reservoir in which, supposing the doubtful structure in Phot. 58, Plate 9, to have been a nectary, honey was stored. It may very likely, however, be due to the decay of soft intervening tissue, or to have been a natural hollow cavity.

The section, though oblique, is not very far out of the transverse, as can be seen by the relative sizes of the carpels. The plane of the section must have lain so that the lower side was on that of the two attached ovules. Such a section must necessarily have passed below the middle of the ovary on the attached side and through the middle or but little above it on the other. The actual area of attachment being so small and the carpels roundish and not vertically extended, it becomes clear that the perianth tube (or the bract) must have been attached to the carpels but a short distance, perhaps only a third of their height. The carpels being then in the main superior, with a slight inferiority of position.

Affinities.—Although Dicotyledons are not entirely shut out from possible affinity with this plant, as there are several genera in which trilocular ovaries are to be found, yet the general appearance and structure of these carpels is much more like those of several typical Monocotyledons than of any Dicotyledon with which we are acquainted.

The trilocular ovary with axile placentation and seeds in two rows is found among the Monocotyledons as a group (though in isolated cases in other families) only in the Liliifloreæ. In this group the Liliaceæ alone have superior ovaries, and would therefore be the most natural family in which to include the fossil. Among the Liliaceæ, though typical with free parts and superior ovaries, there is some variety of organisation. Such a genus as *Aletris*, for example, in which the ovary is semi-superior, with fusion to the perianth for half its length, though more advanced in

these directions than the fossil appears to be, yet indicates a not impossible affinity. In seeming harmony with which is the present distribution of the living genus *Aletris* in Eastern Asia and North America.

This is assuming that the foliar structure of the fossil is a perianth, which seems well founded. It is not impossible, however, that it is a mere bract, and might have been, as in *Saururus*, attached directly to the carpel, though it does not compare with any such living forms we examined. That it was even such an organ as a cupule or disc is not impossible, though there is nothing to favour such a supposition.

On the whole, judging from its detailed structure and general appearance, we incline to place the flower in the Liliaceæ.

Diagnosis :—

CRETOVARIUM, gen. nov.

Ovary trilocular. Placentation axile. Seeds in two rows. Perianth (?) fused to the lower part of the carpels, which are slightly inferior.

CRETOVARIUM JAPONICUM, sp. nov.

Ripe ovary 2 mm. in diameter. Ovary globular and not greater than 3 mm. in height. The wall of the ovary with an inner persistent layer of sclerenchymatous fibres. Six small vascular bundles in the placental axis.

Upper Cretaceous, Hokkaido, Japan.

Conclusion.

The fact that we are describing a flora of which nothing has hitherto been known means that the points which have come to light about the individual plants here described are of necessity very much more isolated, and form a less connected whole, than is the case in dealing with a relatively well-known fossil flora, such as the Carboniferous. As regards the Cretaceous period, we are to-day in an even less advantageous position than were the writers on the Carboniferous thirty years ago, and are in reality only laying foundations of a building the form of which does not yet appear.

Of the majority of the plants described in this paper we have only a single part, and where two or more parts, such as stem and leaves, or stem and roots, are known from the same plant, we must think ourselves very fortunate. This makes it difficult, indeed, to bring the fossils into relation with the plant families as a whole, and even where their position in the natural system can seem assured, they do not all at this stage appear to add very much to the sum of purely botanical knowledge. We trust that the fragments will fit into their places later on, and till then do not wish to add to the already too numerous theories which have inadequate facts as their foundation.

As this is a first and, we hope, not a final paper, the conclusions will not be elaborated at length, but will be confined to the main features of interest in the new field which this work opens up.

The first and most obvious result of the present work is the addition of the following new genera and species to the number of the known plants.

Fungi : *Petrosphaeria japonica*, STOPES and FUJII.

Pteridophyta : *Schizaeopteris mesozoica*, STOPES and FUJII.

Fasciostelopteris Tansleii, STOPES and FUJII. Fern rootlets.

Gymnosperms : *Niponophyllum cordaitiforme*, STOPES and FUJII.

Yezonia vulgaris, STOPES and FUJII.

Yezostrobus Oliveri, STOPES and FUJII.

Araucarioxylon Tankoense, sp. nov.

Cedroxylon Matsumurae, sp. nov.

Cedroxylon Yendoi, sp. nov.

Cunninghamiostrobus yubariensis, STOPES and FUJII.

Cryptomeriopsis antiqua, STOPES and FUJII.

Angiosperms : *Saururopsis nipponensis*, STOPES and FUJII.

Jugloxyylon Hamaoanum, STOPES and FUJII.

Sabiocaulis Sakuraii, STOPES and FUJII.

Populocaulis yezoensis, STOPES and FUJII.

Fagoxylon hokkaidense, STOPES and FUJII.

Cretovarium japonicum, STOPES and FUJII.

Of these, *Yezonia* might be specially mentioned as being of a new type, sufficiently unlike the known Gymnosperms to justify at least the suggestion that it requires a new family to be created for its inclusion, for which we propose the name the *Yezoniaceae*. *Cretovarium*, the flower, has no structures which seem in any way morphologically unique, but it is the first flower to be found in petrified material among the fossils of any age, though impressions of a few flowers are known.

The list of species given above shows that we are dealing with a mixed flora, whose external features were probably not unlike those of the plants of to-day, even the strangest and most exceptional among them in its internal organisation differing but little from a common type of to-day in its external appearance. The mixture of plants in the flora is roughly composed of one-third Angiosperms, one-third Gymnosperms, and one-third lower plants. There is, of course, no petrified flora of Mesozoic age with which this can be compared, but, even in the composition of the various floras known from impressions, there is no parallel case.

In view of the fact that the Cretaceous flora is often spoken of as having a close similarity to that of the present, it is interesting to note that *Yezonia* and *Yezostrobus* have no external feature to indicate the fundamental differences in their internal organisation. The small adpressed leaves of *Yezonia* are quite like

those of the Taxodineæ, while in general appearance the cone of *Yezostrobus* must have been very similar to Abietinean cones of to-day.

The two plants of which we have the greatest number of individuals are the new Gymnosperm *Yezonia* and the Angiosperm *Sabiocaulis*. Of most of the others only one, or in some cases, two specimens are among the fossils already cut. *Yezonia* seems to have been without any doubt the commonest plant of the district; indeed, it appears in many respects to be to this Cretaceous flora what *Lyginodendron* is to the Lower Coal Measures, and, like it, is a plant whose foliage and external appearance do not give the key to its internal organisation, which is of an intermediate type. Had we only had impression material of *Yezonia* it would almost inevitably have been described as "*Thujites*" or some such genus, and the peculiarity of the plant would have passed unnoticed. Knowing its internal structure, however, it stands out as a new and interesting type (see p. 23, *ante*), for in its anatomy it combines the features of several of the higher Gymnosperms, with a suggestion of Cycadean character and with a new type of leaf. Further, there is more than a suspicion that it bore a cone with seeds organised like those of the Palæozoic Pteridosperms. *Yezonia* therefore takes its place as an extinct type full of theoretical value and suggestion. It is also an excellent example of the deceitfulness of the external features of a plant, particularly of a fossil plant, which may serve as an incentive to study the Cretaceous flora more closely. It appears not at all improbable that when we know more about it we shall no longer consider the Cretaceous vegetation as so similar to that of the Tertiary and the present day, and that as a consequence the flora of that period will be seen to be more parallel to the condition of the fauna, which differs so greatly from that of the succeeding geological epoch.

Although such a limited number of plants as are here described can give no complete idea of the forests, yet it is probable that it gives a fairly representative sample of the common plants of the district at the time. They were growing at no great distance from the sea, apparently on land, which was neither swampy nor unusually dry. On the whole, the plants seem to have been those of a warmer region than the locality is at present. The two ferns belong to families typically tropical or sub-tropical. *Niponophyllum*, presumably Cycadean, would indicate tropical or sub-tropical conditions. *Cunninghamiostrobus* suggests the highlands of a sub-tropical region, judging from its likeness to the living members of the family, which are now only found in such parts. The Angiosperms are less decisive, but are rather more characteristic of the warmer portions of the temperate zone than the colder, while the *Sabiaceæ* belong to the monsoon region, tropical East Asia, Brazil, etc. This agrees with the ferns and Gymnosperms in indicating a sub-tropical climate for the Hokkaido region in Cretaceous times.

When we turn to consider the present distribution of the families to which these fossil plants belong, we find that most of them still have representatives in Japan or

Eastern Asia, or in America. The *Schizaeaceæ* and *Dicksoniaceæ* still inhabit the hotter parts of Japan. *Cycas* is at home there in the south. The living *Araucaria*, presumably an ally of the fossil *Araucarioxylon*, is no longer in Japan, nor are *Cedrus* and *Cunninghamia*, though the new second species of the latter, as well as the genus *Taiwania*, are found in Formosa. *Cryptomeria*, though so universal throughout present day Southern Japan, is not now indigenous to Hokkaido. Of the Angiosperms some species of all the families found in the fossil are now found in Japan, while it is interesting to note that the family *Saururaceæ* consists of only three species, which are confined to Eastern Asia and Japan and one to New California in America.

The distribution on the whole, therefore, while not differing fundamentally from that of the present, shows that several plants no longer found in Japan inhabited it in the Cretaceous period, and that the plants on the whole were those of a region which was probably sub-tropical in its climate. As regards *Yezonia*, until the Cretaceous fossils of other districts are known, or until, as is very likely, it appears in a much older formation, nothing can be said as to its distribution in time or space. It is an interesting coincidence that another isolated Gymnospermic type, *Ginkgo*, survived in Japan from very early times till the present geological epoch.

Turning now to the individual plants described in this paper, the fungus *Petrosphæria* is an exceptionally well preserved petrifaction of a fungus; it belongs in all probability to the *Sphaeriaceæ*, but it has no direct phylogenetic value, so far as can be determined at present.

The fern sorus, *Schizæopteris*, leaves one in no doubt as to its inclusion among the *Schizaeaceæ*, the character of its annulus being very clear and characteristic. So small a part of the fructification is known, however, that it is not possible to determine the nature of the sporophyll, and consequently its exact relationship to the other members of the family. Its details, so far as they are known, point in the direction of *Aneimia*, but it does not coincide with the living genus. While several impressions of fossils have been placed in this family, some of them from rocks of a much earlier date, they are mostly of rather an uncertain nature, and this is in any case the first member of the group which occurs in structural petrifactions.

The fern rootlets, with their diarch steles, seem to be identical with the usual ones of the Leptosporangiate ferns of all epochs, and are in no way unusual. It is practically certain that they belong to one or more of the fern stems we have in the nodules.

The leaf *Niponophyllum* is unfortunately known from only one or two separate blades. It offers several points of anatomical interest, which have been entered into fully in the text (p. 17). The general anatomy of the leaf is surprisingly like that of the Palæozoic *Cordaites*, while the nearness of the veins and the absence

of transfusion tissue afford data for a comparative consideration of the leaf structure in living Cycads, *Cordaites*, and *Cycadeoidea*. The points raised will not be recapitulated here, but they suffice to show that the plant was one which may prove to be of considerable anatomical interest when its whole structure is discovered. The plant has entirely died out of the East Asian area, and while its relation to the Australian Cycads is not impossible, it is unlikely.

The Gymnosperm *Yezonia* is the commonest plant of this flora, and at the same time the most interesting. Its several peculiar structures, particularly the organisation of its leaves, with their unique arrangement of vascular tissue and transfusion tissue, are described on p. 26. Although we have no specimen of this plant with its fructification in organic continuity, there exists that constant association with *Yezostrobus* which is sometimes such a valuable suggestion in dealing with fossil fragments. There is also sufficient similarity in anatomical detail between the scale of the seed and the leaf of the plant (see p. 40) to leave but little real doubt as to their identity. Everything marks out *Yezonia* as being one of that company of plant types which are known only from the fossils, and whose structure would never have been imagined had not their actual remains come down to science.

Owing to the lack of absolute proof of continuity with the vegetative parts, *Yezostrobus* must be named and considered separately. Its salient features were described on p. 33. Its chief interest lies in the fact that it bore seeds in a cone, which seeds were massive and organised like those of Cycads, and at the same time had a nucellus free from the integument right down to the base. The seed itself, indeed, was like that of the Palaeozoic *Trigonocarpus*, while it was borne on what seems to have been a simple scale, with only one seed on it. It will be remembered that the supposed vegetative parts have no likeness to *Araucaria*, a genus with which the single-seeded scale might suggest comparison. This and the preceding plant then afford a fascinating field for theoretical and general phylogenetical discussions, from any further excursion into which we intend to refrain for the present.

Passing to the next Gymnosperms on the list, *Araucarioxylon* and *Cedroxylon* neither offer any new anatomical feature beyond the presence of traumatic resin canals in *Cedroxylon*, which are described for this genus for the first time.

In *Cunninghamiostrobus* the organisation is too similar to the living genus to offer any great novelty, although the unusually large size of the scale vascular bundles is a small point worth notice. Lying as the cone did, half exposed in the matrix, some idea was obtained of its external appearance, and it is worthy of note that it is very like several of the Cretaceous cones called *Sequoia*.

Cryptomeriopsis, having stems and leaves attached together, is one of the most complete of the plants described. It seems to differ but slightly from the living genus *Cryptomeria*, and the anatomical observations arising from its comparison

with the recently discovered living genus *Taiwania* refer primarily to the living genus.

Among the Angiosperms, more is known of *Sauruopsis* than of the rest, as it has a stem with roots attached. Its anatomy is of an interesting type, which is very unusual among Angiosperms, but the fossil differs but little from the living members of the group. The other Angiosperms, known only from their secondary wood or stem structure, offer no feature new to anatomy. The genus *Sabiocaulis*, which is the commonest of the fossil Angiosperms we describe, has also a type of stem anatomy comparatively rare among living forms. Unfortunately none shows a new "Pro-Angiosperm" type of anatomy. But we should like to remark here that it seems very doubtful if it would be recognisable as such were the stem alone of a pro-Angiosperm to be forthcoming. After this, if it will not appear too inconsistent, we should like to add that the presence of *Sauruopsis* at this early date makes one pause to consider whether, looked at impartially, anything could be much more primitive than the anatomy of *Sauruopsis*, and, indeed, the *Saururaceæ* as a whole. Had botanists not got accustomed to the existence of *Saururus* among living plants it would surely have attracted the anatomists' attention. It has no large vessels, no differentiation of the wood into vessels and fibres. Its metaxylem elements are exclusively scalariform. No phylogenetic views are here expressed : we wish merely to note the fact, brought to our notice by the discovery of the fossil *Sauruopsis*, that the Saururacean anatomy is of an extraordinarily suggestive description.

Among the Angiosperms there is but one that seems to belong to the Monocotyledons, the flower *Cretovarium*. This, curiously enough, is comparatively abundant. The details of its structure are given on p. 70, with the reasons for the, possibly temporary, placing of it in the Liliaceæ not very far from *Aletris*, a rather exceptional genus with the carpels partly inferior and fused to the perianth. In any case, the structure of this, the first known flower, does nothing to support the recent theories of flower origin, for it is itself apparently so far advanced already as to give no clue to its phylogeny.

Taking the Angiosperms as a whole, there is one Monocotyledon, and five Dicotyledons, and of the latter the whole number belong to the Archichlamydeæ. Four of these belong to the Monochlamydeæ, and the fifth to the Dialypetalæ. We have not yet described all the Angiospermic remains which have passed through our hands, but have chosen the less fragmentary ; hence in the material already available these numbers cannot be said to have any intrinsic value. Sections of the Angiospermic leaves, for example, are particularly abundant, but are so extremely difficult to identify that we have not described any of them in the present paper.

These new fossil plants, then, seem to be an interesting community, consisting of a mixture of old and new types, of higher and lower plants mixed in nicely balanced proportions ; a community which in some respects, at any rate, one could have hardly imagined from the fossil remains hitherto available from the Epoch.

LITERATURE.

- BREBNER (1902). G. Brebner, "On the Anatomy of *Danrea* and other Marattiaceæ," 'Annals of Bot.,' vol. 16, No. 63, pp. 516–552, Plates 22–23, September, 1902.
- CALDWELL (1907). O. W. Caldwell, "Microcycas Calocoma," 'Bot. Gaz.,' vol. 44, pp. 118–139, Plates 10–13, 1907.
- ENGLER and PRANTL. A. Engler and K. Prantl, "Die natürlichen Pflanzenfamilien," Leipzig, 1902.
- FELIX (1883). J. Felix, "Unters. ueber fossile Hölzer," Parts 1–4, 'Zeit. d. Deut. Geol. Gesell.,' 1883–1894.
- Idem* (1894). J. Felix, "Studien ueb. fossile Pilze," 'Zeit. d. Deut. Geol. Gesell.,' Bd. 46, pp. 269–280, Taf. 19, 1894.
- FISCHER (1885). H. Fischer, "Beitr. z. vergl. Anatomie d. Markstrahlgew. u. d. jähr. Zuwachszenen," 'Flora,' 1885.
- FRITSCH (1903). F. E. Fritsch, "The Use of Anatomical Characters for Systematic Purposes," pp. 177–184, 'New Phytologist,' 1903.
- GOTHAN (1905). W. Gothan, "Zur Anat. lebender u. foss. Gymnospermen-Hölzer," Inaug. Dissert., Jena, pp. 1–41, text-figs., 1905.
- GWYNNE-VAUGHAN (1903). D. T. Gwynne-Vaughan, "Observations on the Anatomy of Solenostelic Ferns," Part 2, 'Annals of Bot.,' vol. 17, pp. 689–742, Plates 33–35, 1903.
- Idem* (1908). D. T. Gwynne-Vaughan, "On the Real Nature of the Tracheæ in Ferns," 'Annals of Bot.,' vol. 22, pp. 517–523, July, 1908.
- HARTIG (1880). R. Hartig, "Unters. aus d. Forstbot. Institut zu München," Taf. 1–9, pp. 58–61, Berlin, 1880.
- HAYATA (1907). B. Hayata, "On *Taiwania* and its Affinity to other Genera," 'Bot. Mag. Tokio,' vol. 21, No. 241, pp. 21–27, Plate 1, 1907.
- HEER (1874). O. Heer, "Die Kreide-Flora d. Arctischen Zone," 'Kong. Svenska. Veten. Akad. Handl.,' Bd. 12, No. 6, pp. 1–135, 38 Plates.
- HERBST (1894). A. Herbst, "Beitr. z. Kennt. d. Markstrahlen dicotyler Kräuter u. Stauden." Several parts, 1 Plate, 'Bot. Central.,' Bd. 57, No. 9, 1894.
- HOLLIK and JEFFREY (1906). A. Hollick and E. Jeffrey, "Affinities of certain Cretaceous Remains commonly referred to the Genera *Dammara* and *Brachiphyllum*," 'Contrib. from the New York Bot. Gard.,' No. 79; 'Amer. Nat.,' vol. 40, pp. 189–216, Plates 1–5, New York, 1906.
- HOULBERT (1893). C. Houlbert, "Recherches s. l. struct. comparée du Bois Secondaire dans les Apétales," 'Ann. d. Sci. Nat. Bot.,' tome 17, Paris, 1893, pp. 1–179, Plates 1–7.

- JEFFREY (1905). E. C. Jeffrey, "The Compar. Anat. of the Coniferales. Part 2.—
The Abietineæ," 'Mem. Bost. Soc. Nat. Hist.,' vol. 6, No. 1, pp. 1–37
Plates 1–7, Boston, 1905.
- KNY (1890). L. Kny, "Ein Beitr. z. Kennt. d. Markstrahlen dicotyler Holzgewächse,"
'Bericht. d. Deut. Bot. Gesell.,' Bd. 8, pp. 176–187, Taf. 13, 1890.
- LIGNIER (1907). O. Lignier, "Végétaux foss. d. Normandie, Bois Divers," 'Mém. Soc.
Linn. d. Normandie,' pp. 239–332, Plates 17–23, Caen, 1907.
- LOTSY (1907). J. P. Lotsy, "Vorträge ü. Botan. Stammesgeschichte," 'Verlag v.
Fischer,' Jena, 1907, 8vo, pp. 1–828.
- McNICOL (1908). Mary McNicol, "On Cavity Parenchyma and Tyloses in Ferns,"
'Annals of Bot.,' vol. 22, pp. 401–413, Plate 25, 1908.
- NÖRDLINGER (1852–88). H. Nördlinger, Querschnitte v. hundert Holzarten,"
Stuttgart, text and sections, 1852–1888.
- OLIVER (1904). F. W. Oliver, "On the Structure and Affinities of *Stephanospermum*,
Brongn., a Genus of Fossil Gymnosperm Seeds," 'Trans. Linn. Soc. Lond.,'
Botany, vol. 6, Part 8, pp. 361–400, Plates 41–44, 1904.
- PORSCH (1905). O. Porsch, "Der Spaltöffnungsapparat im Lichte d. Phylogenie,"
'Verlag. v. Fischer,' Jena, 1905.
- REISS (1907). K. Reiss, "Unters. ü. fossile Hölzer aus Japan," Inaug. Dissert.,
Leipzig, Publ. at Rostock, 1907.
- SALMON (1903). E. S. Salmon, "Cercosporites, sp., a New Fossil Fungus," 'Journ. of
Bot.,' vol. 41, pp. 127–130, text-fig., 1903.
- SCOTT and MASLEN (1907). D. H. Scott and A. J. Maslen, "The Structure of the
Palaeozoic Seeds, *Trigonocarpus Parkinsoni*, Brongn., and *Trigonocarpus
Oliveri*, sp. nov.," Part 1, 'Annals of Bot.,' vol. 21, pp. 89–134, Plates
11–14, 1907.
- SEWARD and FORD (1905). A. C. Seward and Sibille O. Ford, "The Araucariaceæ,
Recent and Extinct," 'Phil. Trans.,' B, vol. 198, pp. 305–411, Plates
23 and 24, 1905.
- SHOVE (1900). R. F. Shove, "On the Structure of the Stem of *Angiopteris evecta*,"
'Annals of Bot.,' vol. 14, No. 50, September, 1900, pp. 497–525,
Plates 28 and 29.
- SOLEREDER (1908). H. Solereder, "Systematic Anatomy of the Dicotyledons,"
vols. 1 and 2, English Translation, Oxford, 1908.
- STOPES (1903). M. C. Stopes, "On the Leaf Structure of Cordaites," 'New
Phytologist,' pp. 91–98, Plate 9, London, 1903.
- Eadem (1904). M. C. Stopes, "Beiträge z. Kennt. d. Fortpflanzungsorgane d.
Cycadeen," 'Flora.,' Bd. 93, Heft 4, pp. 435–482, 'Flora,' 1904.
- Eadem (1909). M. C. Stopes, "Plant-containing Nodules from Japan," 'Quart.
Journ. Geol. Soc.,' vol. 65, pp. 195–205, Plate 9, 1909.
- STOPES and WATSON (1907). M. C. Stopes and D. M. S. Watson, "On the Present

- Distribution and Origin of the Calcareous Concretions in Coal Seams known as 'Coal Balls,'" 'Phil. Trans.,' B, vol. 200, pp. 167-218, Plates 17-19, 1907.
- TANSLEY and LULHAM (1905). A. G. Tansley and R. B. Lulham, "A study of the Vasc. System of *Matonia pectinata*," 'Annals of Bot.,' vol. 19 (No. 76), pp. 475-519, Plates 31-33, October, 1905.
- THOMSON (1905). R. B. Thomson, "The Megaspore Membrane of the Gymnosperms," 'University of Toronto Studies,' Biol. Ser. 4, 1905.
- WIELAND (1906). G. R. Wieland, "American Fossil Cycads," publ. by the Carnegie Inst. of Washington, pp. 1-259, Plates 1-50, Washington, 1906.
- WORSDELL (1897). W. C. Worsdell, "On Transfusion Tissue, its Origin and Function in the Leaves of Gymnospermous Plants," 'Trans. Linnean Soc. London,' Botany, vol. 5, Part 8, pp. 301-319, Plates 23-26, London, 1897.
- VATER (1884). H. Vater, "Die fossilen Hölzer d. Phosphoritlager d. Herzogth. Braunschweig," 'Zeit. d. Deut. Geol. Gesell.,' pp. 783-853, Taf. 28, 1884.
- YABE (1903). H. Yabe, "Cretaceous Cephalopoda from the Hokkaido," 'Journ. Coll. Sci. Imp. Univ. Tokio,' vol. 18, pp. 1-55, Plates 1-7, 1903.
- YOKOYAMA (1889). M. Yokoyama, "Jurassic Plants from Kaga, Hida, and Echizen," 'Journ. Coll. Sci. Japan,' vol. 3, pp. 1-66, Plates 1-14.
- ZEILLER (1907). R. Zeiller, "Les Progrès de la Paléobotanique de l'Ère d. Gymnospermes," 'Prog. Rei Bot.,' 2, Heft 1, pp. 171-226, 18 figs., 1907.
- ZITTEL (1891). K. A. Zittel, "Traité d. Paléontologie, Part 2, Paléophytologie," Schimper and Schenk (translation), Paris, Munich, and Leipzig, 1891.

[NOTE.—Since the foregoing was in the press we have received the very interesting monograph by Dr. HOLICK and Prof. JEFFREY on American Cretaceous Gymnosperms. So far as we can judge at present, none of our types coincide with those described in this paper, but some of the specimens on which one of us is working (M. C. S.) raise points touched on by HOLICK and JEFFREY, and would have been included in the present paper had their monograph appeared earlier. Unfortunately it did not reach us in time for us to make any use of it in the course of our work.]

ACKNOWLEDGMENTS.

We have to acknowledge invaluable assistance during this work, which would have been beyond our powers but for the courteous and kindly help rendered by people too numerous to mention here by name. The Government Grant Committee of the Royal Society made it possible for one of the authors (M. C. S.) to go to Japan and remain there for a year and a half. During this time the Government of Japan, through its departments, the Imperial University of Tokio and the Agricultural University of Sapporo, and the Local Government of Hokkaido, was helpful in every possible way. In the course of both collecting expeditions the Tanco Coal-mine Company of Hokkaido gave much assistance and hospitality. In the Imperial University of Tokio the work was done in the Botanical Institute, where the Director, Prof. MATSUMURA, offered us every facility possible. To the Dean of the Science College, Prof. SAKURAI, we are indebted for much friendly help and special facilities for work. While finishing the paper in England, one of us (M. C. S.) is indebted both to Prof. OLIVER, of University College, London, for hospitality in his laboratory, and to Prof. WEISS, of Manchester University, in whose department the work was completed.

All the figured sections have been presented, or will shortly be presented, to the British Museum of Natural History, London.

DESCRIPTION OF FIGURES.

The authors are much indebted to Mr. SALISBURY for Phot. 12, 49, and 52, and to Mr. WATSON for Phot. 60. The other drawings and photos were prepared by M. C. STOPES.

(Drawings in the plates made with the aid of the camera lucida.)

PLATE 1.

Figs. 1-6.—*Petrosphæria japonica*, STOPES and FUJII.

Fig. 1.—Cells of the cortex of *Saururopsis* infested with hyphæ of the fungus. $\times 500$.

Fig. 2.—End of a hypha of *Petrosphæria*, cut off by a transverse septum and much swollen and thickened. $\times 750$.

Fig. 3.—Hypha of the same, irregularly thickening and swelling. $\times 750$.

Figs. 4 and 5.—Nests of thickened "cells" in the periderm of the host, showing the common form in which they occur. $\times 750$.

Fig. 6.—Section through one of such masses as are shown in figs. 4 and 5. This shows the very thick walled nature of the plectenchyma. *h.*, hyphæ, apparently connected with the mass, possibly germinating from it. $\times 800$.

Fig. 7.—*Fasciotelopteris Tansleii*, STOPES and FUJII.

Transverse section of part of a stele of the main axis, showing :—

- g.* Ground tissue, thick walled (*cf.* Phot. 2, Plate 2, *g.*).
- en.* Endodermis.
- p.* Pericycle.
- ph.s.* Phloem sheath.
- t.ph.* Thickened cells, presumably phloem.
- ph.sv.* Cells, presumably sieve tubes.
- w.s.* Wood sheath.
- x.* Xylem. $\times 180$.

Figs. 8 and 9.—Seed of *Yezostrobus Oliveri*, STOPES and FUJII.Fig. 8.—Longitudinal section of a part of the seed (*cf.* Phot. 11, Plate 3).

- o.f.* Outer flesh of integument, with *c.* secretory or resinous cells (?).
- st.* Stone layer of the integument.
- i.f.* Inner flesh of the integument.
- i.e.* Epidermis bounding the inner flesh of the integument.
- sp.* Space between the integument and the nucellus.
- en.* Epidermis bounding the nucellus.
- n.* Cells of the nucellus.

Fig. 9.—A few of the cells from the stone of the seed, showing the irregular mingling of transversely and longitudinally running elements.

- s.* Ordinary stone cells, showing the pit canals.
- b.* Cells with walls rather less thickened and filled with a blackened mass.

Fig. 10.—Medullary rays of *Cedroxylon Matsumuræ*.

Part of a radial section of a medullary ray, crossing poorly preserved tracheids, but showing structures highly suggestive of nuclei in the ray cells.

Fig. 11.—*Cryptomeriopsis antiqua*, STOPES and FUJII.

External appearance of leaf at L. Broken across in the surface *s.* are other leaves of the plant, *l.* $\times 2$.

PLATE 2.

Phot. 1.—*Schizaeopteris mesozoica*, STOPES and FUJII.

Photo of the sorus, with numerous sporangia attached to, and in the neighbourhood of, the sporophyll.

sp. Sporangium, attached at *a.*

(Compare text-fig. 3 for details, and text-figs. 1 and 2 for diagrams of the sorus and sporangia.) $\times 45$.

Photos. 2 and 3.—*Fasciostelopteris Tansleii*, STOPES and FUJII.

Phot. 2.—Portion of the main axis, showing the very curved band-like strands of wood.

- x.* Xylem.
- c.* Cortical tissues.
- g.* Central ground tissue.

(Compare text-diagram 4.)

Phot. 3.—Part of the ground tissue and vascular strand of the main axis.

- g.* Ground tissue in the neighbourhood of the stele, showing its extremely thick walls.
- x.* Xylem of the stele.

(Compare Plate 1, fig. 7, for details of the stele.)

Phot. 4.—Transverse section of a fern rootlet.

Showing the diarch stele, thickened inner cortex, and large-celled outer cortex. $\times 55$.

Photos. 5–8.—*Yezonia vulgaris*, STOPES and FUJII.

Phot. 5.—Transverse section of the main axis, showing secondary wood.

- p.* Pith.
- p.s.* Nests of sclerenchyma in the pith.
- px.* Protoxylems.
- tw.* "Thin-walled" wood.
- kw.* "Thick-walled" wood.
- r.* Secretory canals.
- c.* Cortex.

Phot. 6.—Part of the wood of the main axis.

- p.* Pith cells.
- px.* Protoxylems.
- w.* Metaxylem.
- kw.* "Thick-walled" wood.
- tw.* "Thin-walled" wood.

(Compare Phot. 7.)

Phot. 7.—Detail of the wood, showing the "thick-walled," *kw.*, on the same radii as the "thin-walled," *tw.*

Phot. 8.—Leaf base attached to the main axis, *a.*

- r.* Large irregular secretory passages.
- tr.* Zone of transfusion tissue.
- sc.* Strands of hypodermic sclerenchyma, alternating with soft tissue into which the stomates open.

(Compare text-diagram 11.)

PLATE 3.

Phot. 9.—*Yezonia vulgaris*, STOPES and FUJII.

A tangential section through a leaf surface, showing the rows of stomates, *st.*, alternating with the strands of hypodermic sclerenchyma, *scl.* *m.*, general soft ground tissue of the leaf.

Photos. 10–13.—*Yezostrobus Oliveri*, STOPES and FUJII.

Phot. 10.—Longitudinal section of the seed attached to the scale.

- x.* Direction of axis of the seed.
- sc.* Scale. *int.* Integument.
- ne.* Nucellar epidermis.
- m.* Macrospore.
- sc.²* Scales of other seeds.

(*Cf.* text-fig. 13.) ×3·6

Phot. 11.—Part of the base of seed in Phot. 10 enlarged.

- ne.* Nucellar epidermis.
- s.* Space between nucellus and integument.
- ie.* Epidermis of inner integument.
- st.* Stone.
- t.* Tracheids at the base of the seed.

Phot. 12.—Apex of seed in Phot. 10 enlarged.

- of.* Crushed streak, remnant of outer flesh.
- st.* Stone.
- if.* Inner flesh.
- ie.* Epidermis of inner flesh.
- s.* Space between integument and nucellus.
- ne.* Epidermis of nucellus.
- m.* Macrospore membrane.
- my.* Base of micropyle.

Phot. 13.—Vascular strand of seed in transverse section, *v.*; it lies just outside the stone cells, *st.* The position of the outer flesh (which has largely decayed) is marked at *of.*

Photos. 14–16.—*Niponophyllum cordaitiforme*, STOPES and FUJII.

Phot. 14.—Portion of leaf in transverse section, to show the numerous parallel veins.

- u.* Upper surface of leaf.
- l.* Lower surface of leaf.

(Compare diagrams in text-figs. 5–7.)

Phot. 15.—A single vascular bundle from the leaf, showing :—

- px.* Protoxylem.
- x.* Xylem.
- os.* Outer sheath cells of bundle sheath.
- ph.* Space where phloem lay.

Phot. 16.—Bundle and some of the surrounding tissue of the leaf.

- sc.* Sclerenchyma above the bundle.
- p.* Palisade cells.
- os.* Outer bundle sheath.
- ss.* Inner, thick-walled bundle sheath.
- x.* Xylem.
- ph.* Position of phloem.

(Compare text-fig. 7.)

Phot. 17 and 18.—*Araucarioxylon Tankoense*, sp. nov.

Phot. 17.—Transverse section of the wood.

Phot. 18.—Transverse section of part of the wood in Phot. 17, on a larger scale, to show the rows of pittings in the walls.

- r.* Pits in radial walls.
- t.* Pits in tangential walls.

PLATE 4.

Phot. 19.—*Yezonia vulgaris*, STOPES and FUJII.

A single secretory passage in an old stem, within which a cork-like layer (*l.*) is forming.

Phot. 20–23.—*Cedroxyton Matsumurae*, sp. nov.

Phot. 20.—Transverse section of the secondary wood, showing well-marked annual rings.

Phot. 21.—Summer and autumn wood, enlarged to show the details of the tracheids.

Phot. 22.—Longitudinal section of some tracheids, to show pitting on the walls, in single and double rows.

Phot. 23.—Longitudinal section, to show the medullary rays; single cells broad and of varying heights.

Phot. 24–26.—*C. Yendoi*, sp. nov.

Phot. 24.—Transverse section of the secondary wood, showing a row of traumatic resin canals, *tr.* (vertically running canals).

Phot. 25.—Tangential section, showing the medullary rays, *m.*, and in two of them the horizontally running traumatic resin canals, cut across, *tr.*

Phot. 26.—Tangential section of the wood, showing the small medullary cells; a single row of cells broad and two or three high.

PLATE 5.

Photos. 27–34.—*Cunninghamiostrobus yubariensis*, STOPES and FUJII.

Phot. 27.—Natural size view of the cone which projected through the nodule surface before cutting.

Phot. 28.—Part of transverse section through a scale.

- v. Vascular strands.
- t. Transfusion tracheids between them.
- h. Hypodermic row of sclerised cells.
- g. Secretory canals.

Phot. 29.—Single scale in transverse section. (The lateral expansions have been cut off in the photo. Compare text-fig. 15.)

- v. Row of vascular bundles.
- p. Pad of tissue on which presumably the seeds were borne.

Phot. 30.—Part of scale, to show the large undivided vascular bundle, v.

From this a small strand, s., is coming off.

- g. Large secretory canal below the bundle (cf. text-fig. 15).

Phot. 31.—High power view of the transfusion tracheids.

Phot. 32.—A scale from the apex of the cone, with three protuberances, a, b, and c, which are presumably ovules.

(Cf. Phot. 33.)

Phot. 33.—Protuberance a of Phot. 32 enlarged, showing the regular, closely packed tissue, unlike that of the ground tissue of the scale.

Phot. 34.—The exit of a scale strand, sc.t., from the main axis tissues, ax., showing its large size and semicircular form.

PLATE 6.

Photos. 35–41.—*Cryptomeriopsis antiqua*, STOPES and FUJII.

Phot. 35.—Section through main axis, surrounded by leaf bases.

- p. Pith.
- x. Secondary wood.
- lt. Leaf trace passing through the secondary wood.

Phot. 36.—Tangential longitudinal section of the wood of the main axis, to show the medullary rays, one cell broad and nearly all one cell in height.

Phot. 37.—Transverse section of part of the secondary wood, x., with outside it the cambium zone, c., and the phloem, ph. et., cortical cells.

Phot. 38.—Transverse section of the base of a leaf.

- G. Central secretory canal.
- g.* Lateral secretory canals.
- v.* Vascular strand. *tr.* Transfusion tracheids.
- a, a.* Position of stomates.

Phot. 39.—Transverse section toward the tip of the leaf.

- G. Single central secretory canal, the lateral ones have died out by this level.
- tr.* Transfusion tracheids.

Phot. 40.—Enlargement of the central secretory canal, G., such as is seen in Phot. 38, showing two or three cells, like an epithelial lining, *e.*

- v.* Vascular bundle.
- tr.* Transfusion tracheids.

Phot. 41.—Longitudinal view of strand of transfusion tracheids, showing the markings on their walls.

PLATE 7.

Phot. 42–47.—*Saururopsis nipponensis*, STOPES and FUJII.

Phot. 42.—Transverse section of part of the axis.

- v.* Vascular bundles.
- c.* Cortical regions.
- p.* Periderm.

Phot. 43.—Part of the wood from such a bundle as that shown in Phot. 42, enlarged, showing the uniform size of the wood elements.

Phot. 44.—Longitudinal section of the wood elements, showing their scalariform thickenings.

Phot. 45.—Transverse section of region outside the wood, which looks very suggestive of phloem tissue.

Phot. 46.—Section of outer part of the cortex, with the strand of an outgoing rootlet, showing the curved form of the strand coming from a tangentially running bundle in the cortex.

- p.* Periderm of cortex.
- t.* Tangentially running strand.
- r.* Strand going out to rootlet.

Phot. 47.—Transverse section of a rootlet running in the cortex.

Phot. 48.—*Jugloxyylon Hamaoanum*, STOPES and FUJII.

Transverse section of the wood, showing vessels, regularly arranged fibres, and medullary rays.

PLATE 8.

Phot. 49.—*Populocaulis yezoensis*, STOPES and FUJII.

Phot. 49.—Transverse section of the stem, showing the five-rayed pith, the secondary wood with medullary rays, and a portion of the cortex.

Phot. 50—53.—*Jugloxyylon Hamaoanum*, STOPES and FUJII.

Phot. 50.—Transverse section of secondary wood, showing the broad medullary rays alternating with the narrow ones, and the numerous large vessels.

Phot. 51.—Part of wood of Phot. 50 enlarged, transverse section.

bm. Broad medullary ray; note the oblique tangential walls of the elements composing it.

nm. Narrow medullary rays.

v. Vessels.

f. Wood fibres, thick-walled, in which pittings can be seen (*cf.* Phot. 52).

Phot. 52.—Wood fibres enlarged to show the pit canals, *p.*

l. Lumen of fibres.

v. Vessels, only partly within the field of the photograph.

Phot. 53.—Tangential section of a broad medullary ray.

Phot. 54.—*Sabiocaulis Sakuraii*, STOPES and FUJII.

Part of the stem in transverse section.

p. Pith.

v. Vascular bundles.

c. Cambium zone.

ph. Phloem, capped by hard bast fibres, *hb.*

cor. Cortex.

PLATE 9.

Phot. 55—57.—*Sabiocaulis Sakuraii*, STOPES and FUJII.

Phot. 55.—Part of a bundle from Phot. 54, Plate 8, enlarged.

v. Wood vessels.

c. Cambium zone.

ph. Phloem.

hb. Hard bast fibres, forming a solid cap behind the bundle.

cor. Cortex.

Phot. 56.—Transverse section of a complete minute twiglet, showing a ring of bundles arranged in a slightly horseshoe-shaped fashion.

Phot. 57.—Part of the bundles of an older stem in transverse section.

- v. Vascular bundle, radially extended by secondary growth.
- mr. Medullary rays, continuous between all the primary bundles. *m.sc.*, sclerised outer portions of the rays.
- c. Region of cambium.
- ph. Phloem.
- hb. Hard bast cap.
- cor. Cortex.

Photos. 58–60.—*Cretovarium japonicum*, STOPES and FUJII.

Phot. 58.—Transverse section of the trilocular ovary, with perianth, *p.*, partly round it.

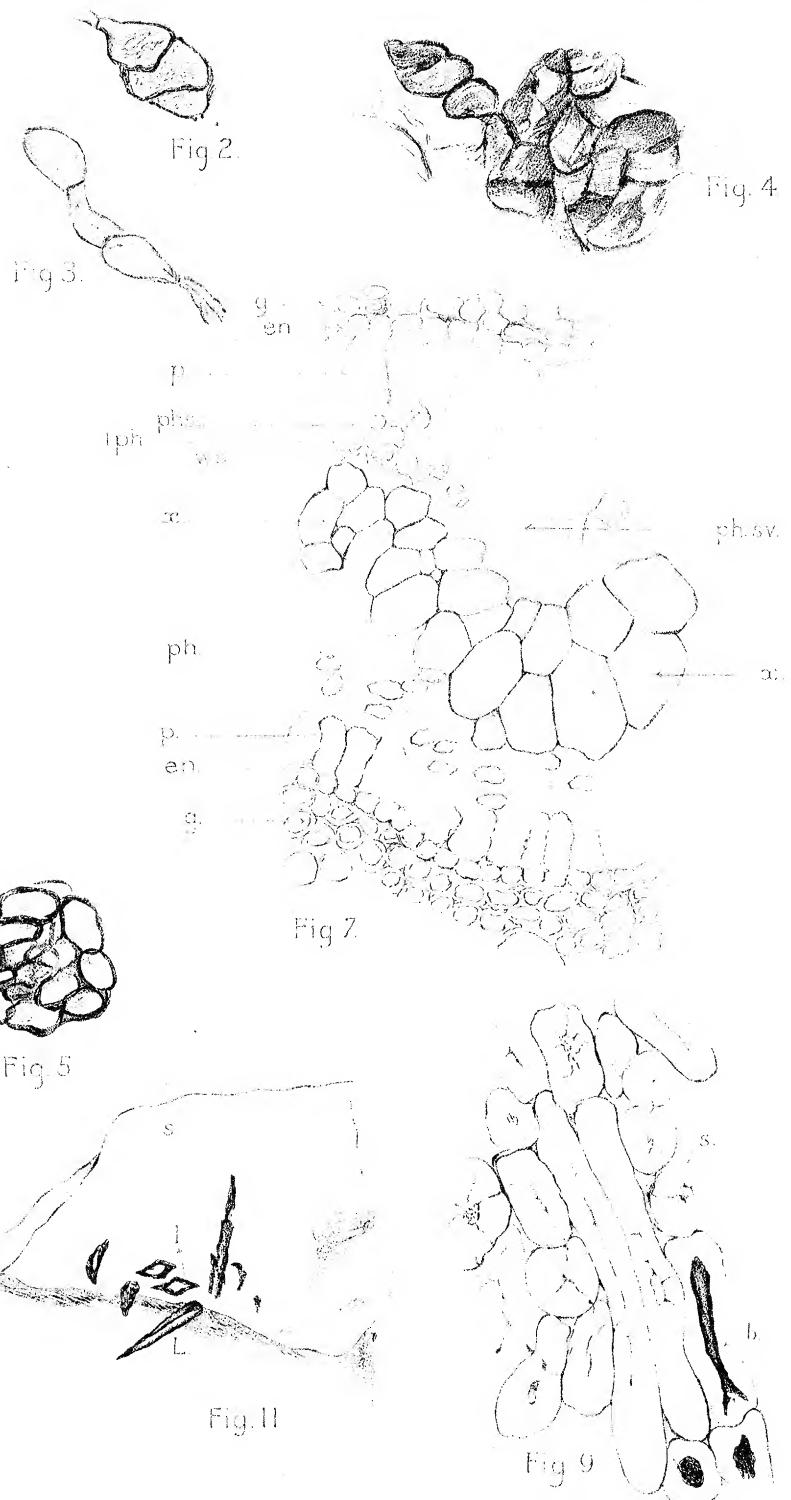
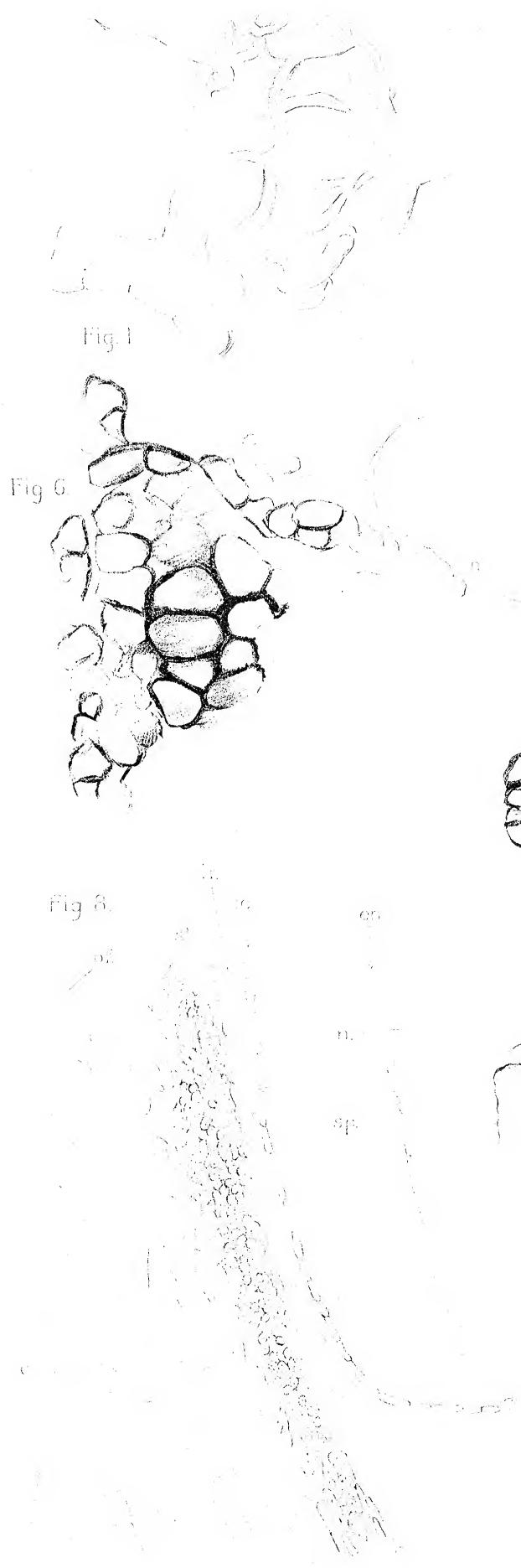
Phot. 59.—Slightly oblique section of the trilocular ovary, with perianth, *p.*

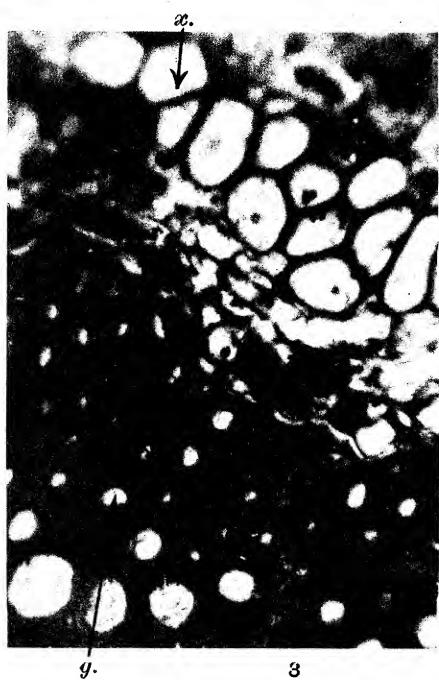
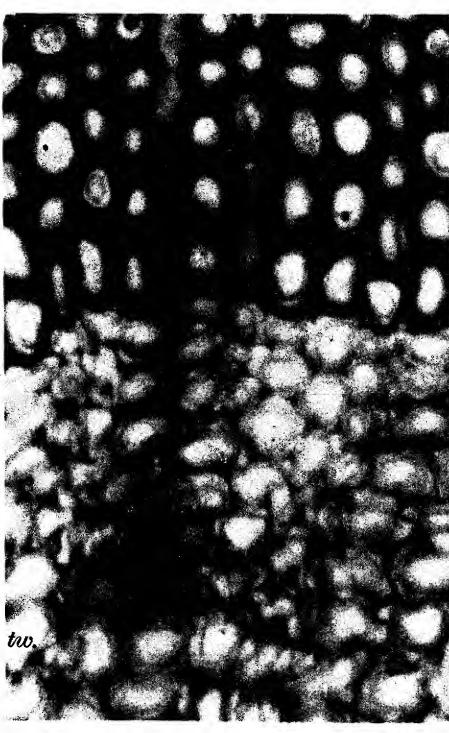
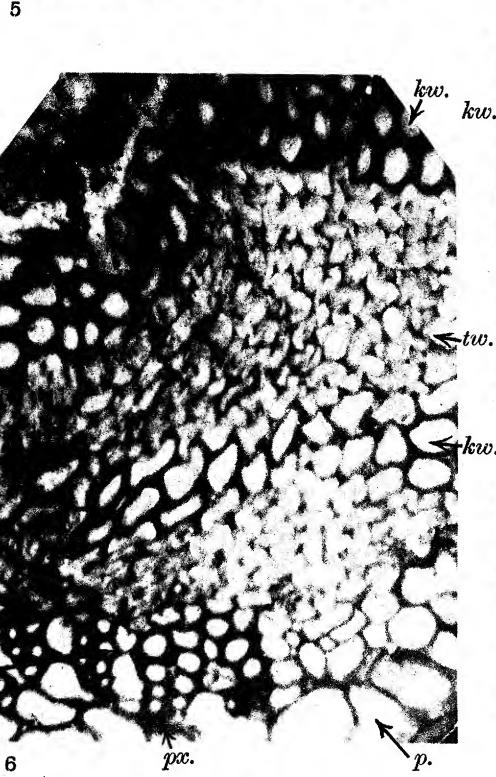
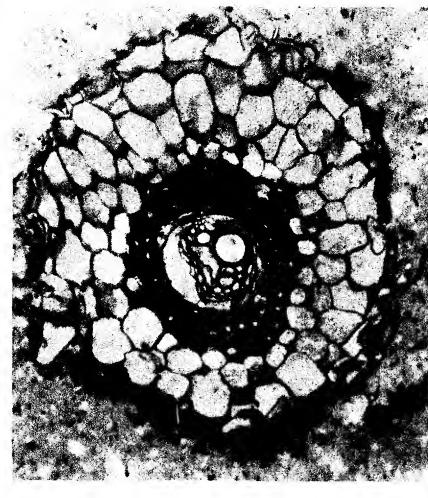
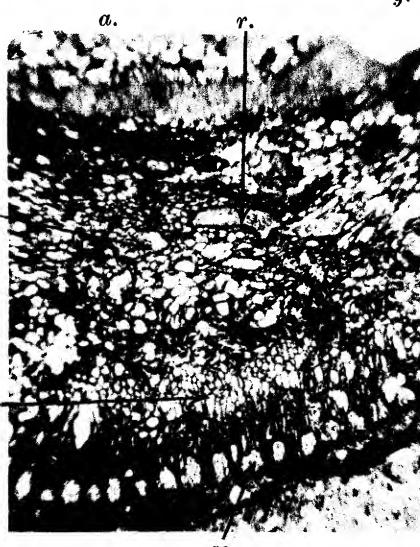
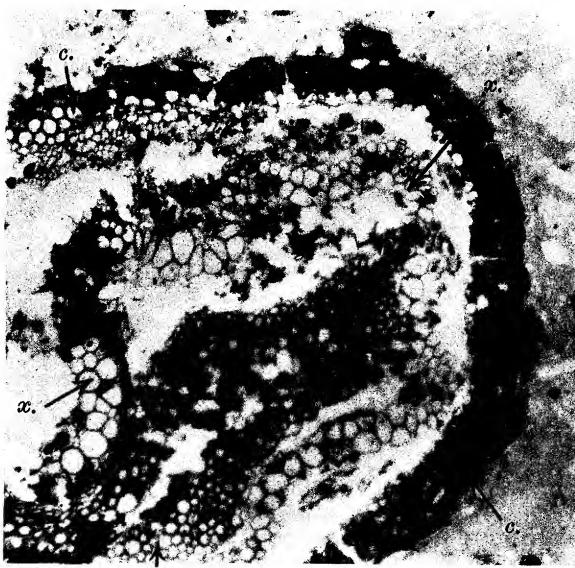
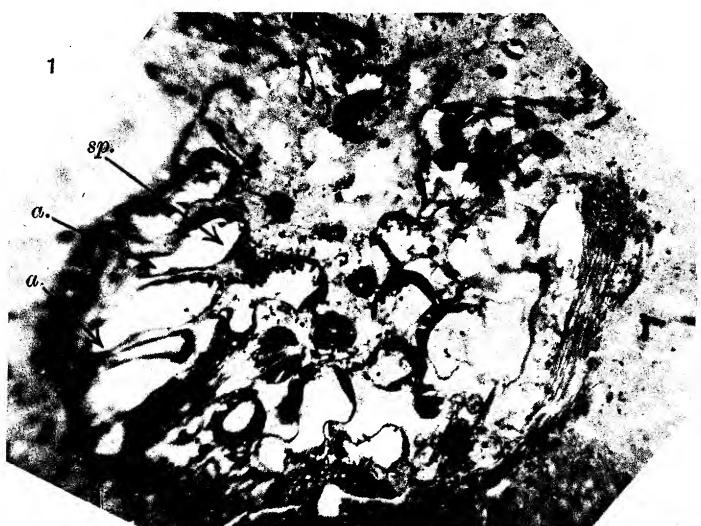
The loculi, *a* and *b*, are attached to the perianth at points *t*, *t.* *s.*, small space between carpels and perianth.

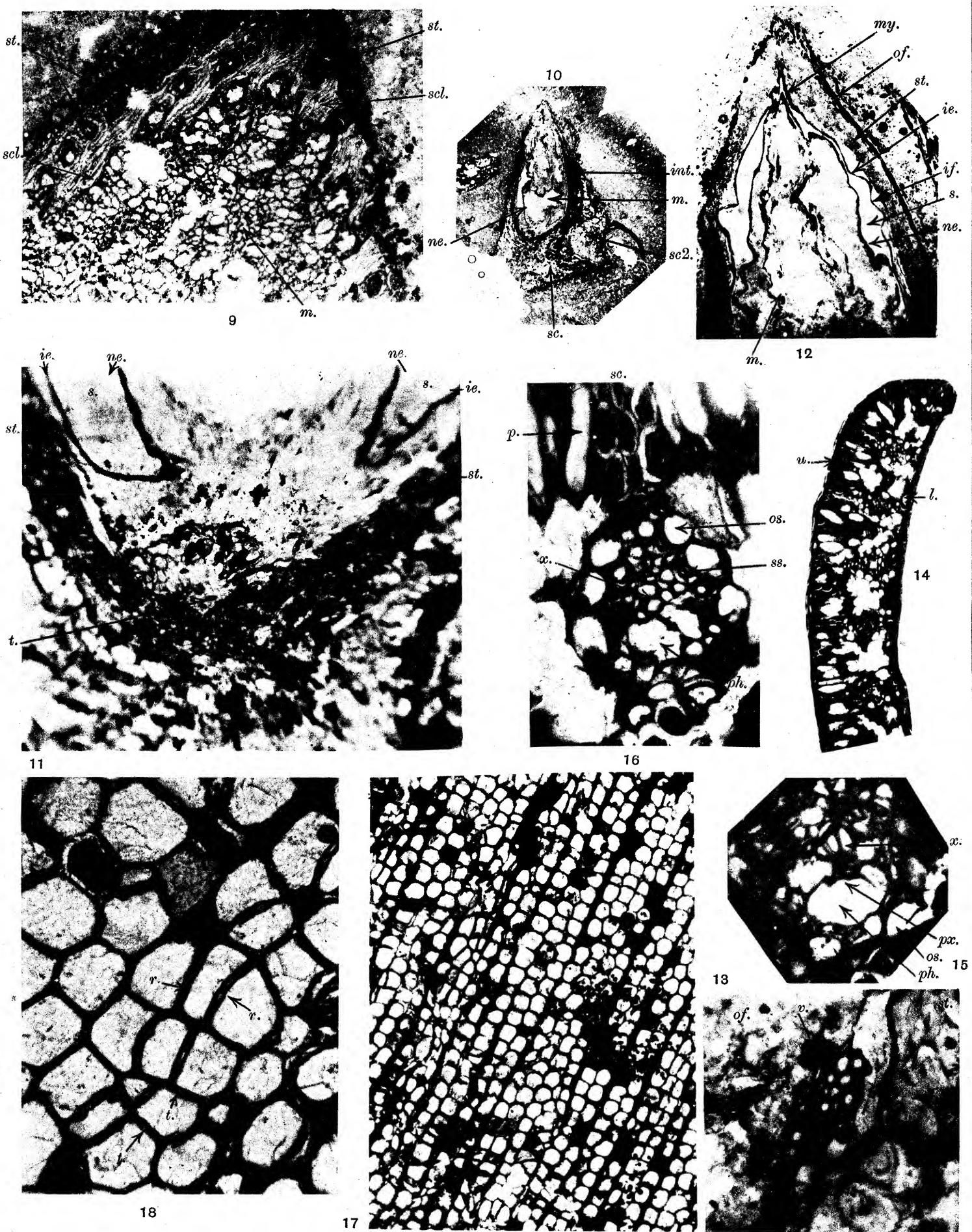
Phot. 60.—Transverse section of part of three carpels from another ovary of *Cretovarium*.

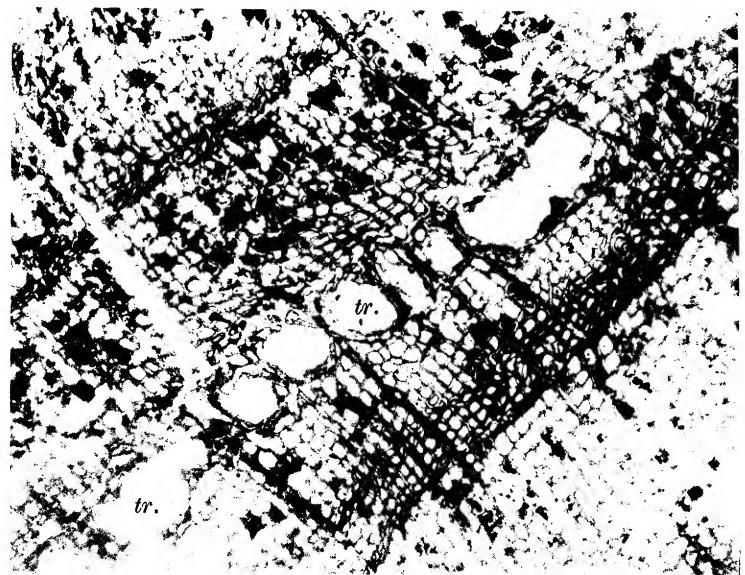
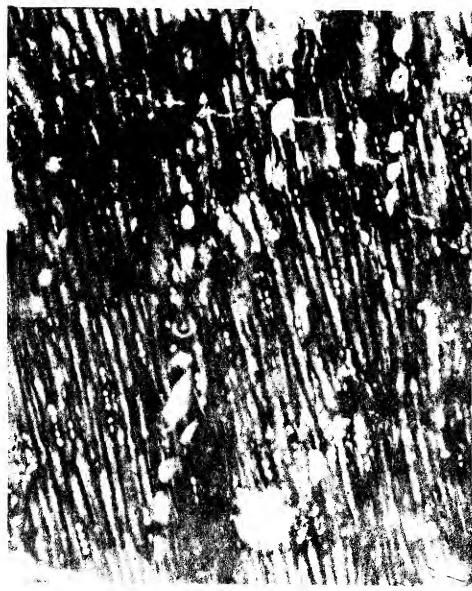
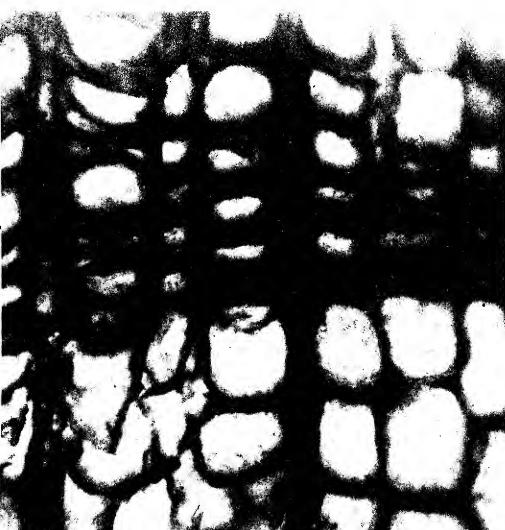
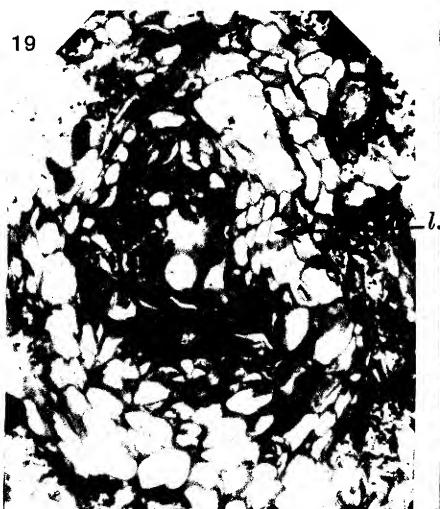
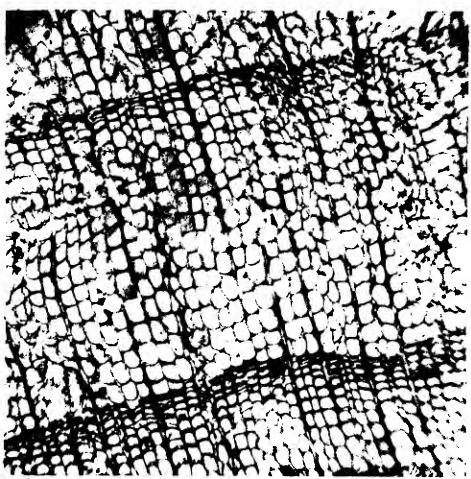
- f.* Inner fibrous layer of ovary wall.
- s.* Outer layer, probably soft tissued, represented by crushed blackened mass.
- pl.* Placentæ, two in each carpel, indicating that the ovules were in two rows.

× 40.







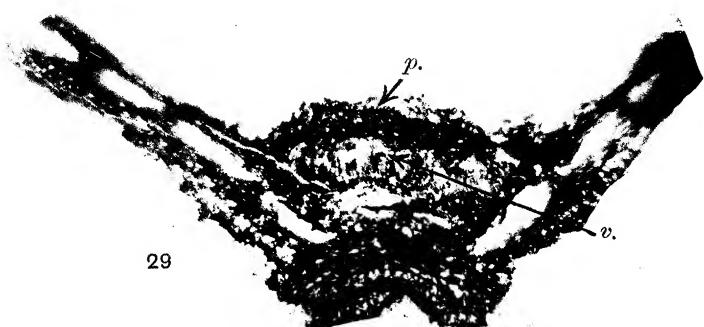




27



28



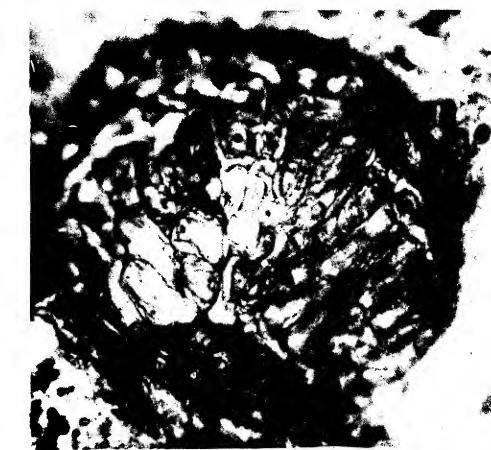
29



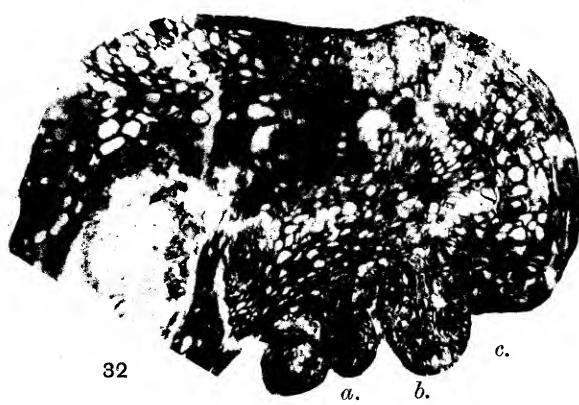
31



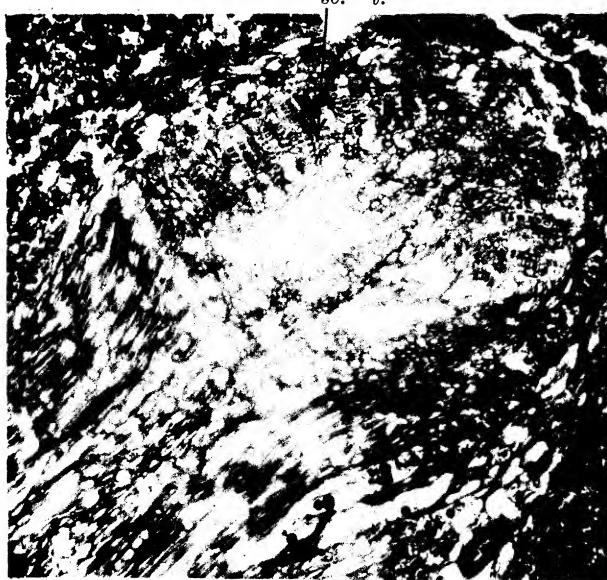
30



33

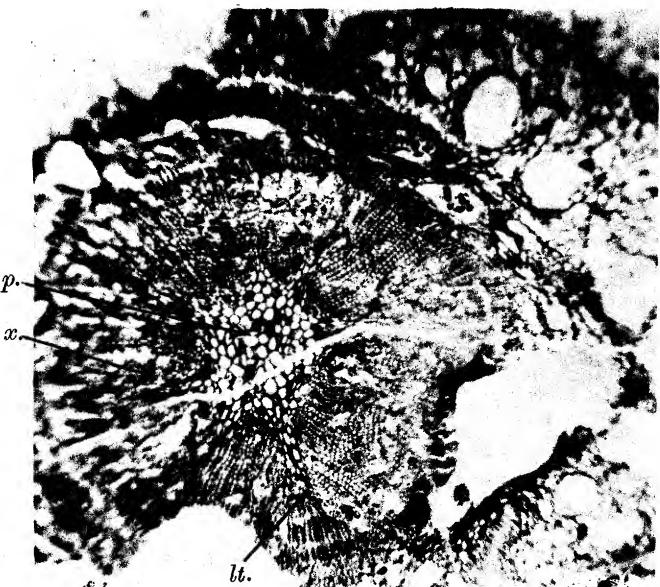


32

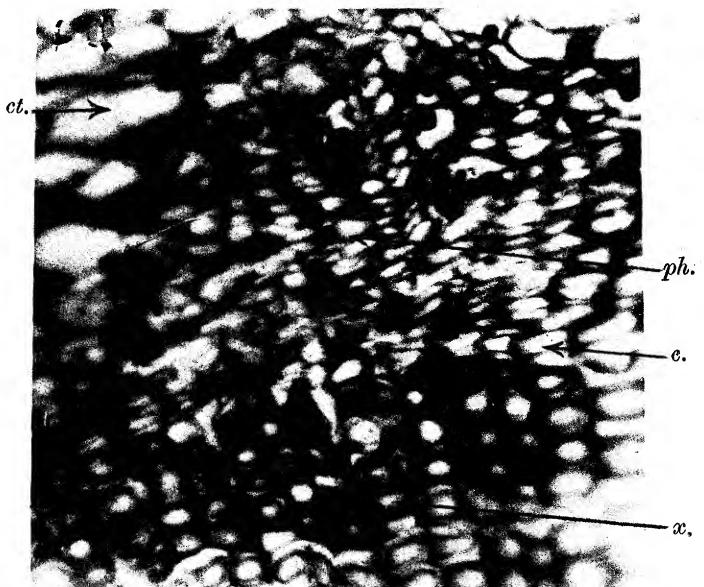


34

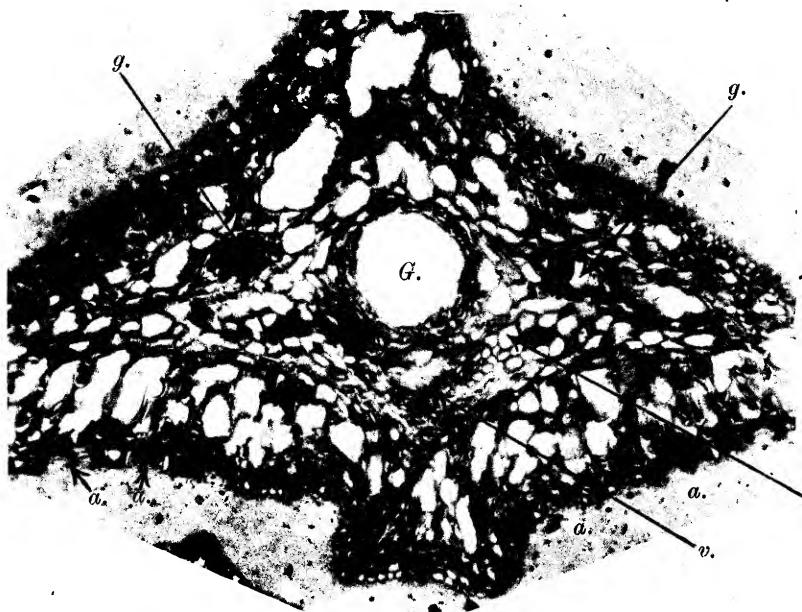
ax.



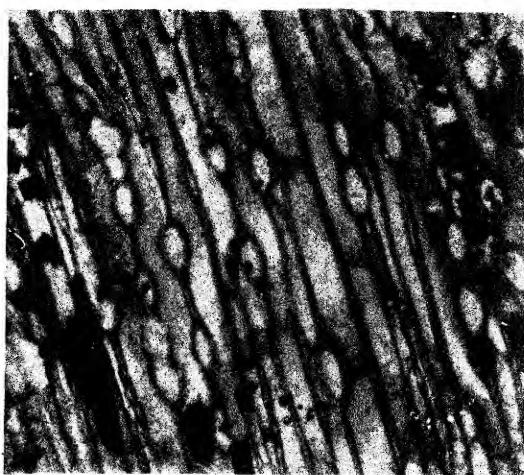
35



37



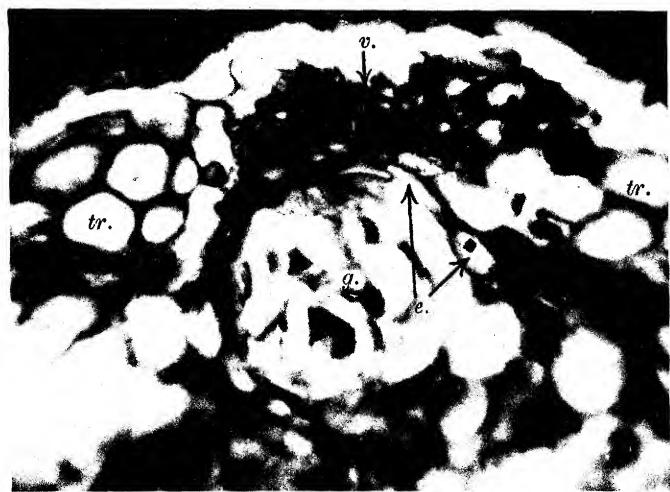
38



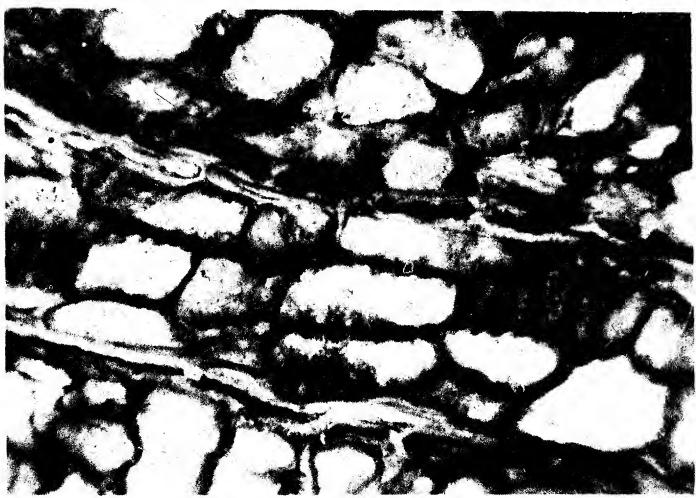
36



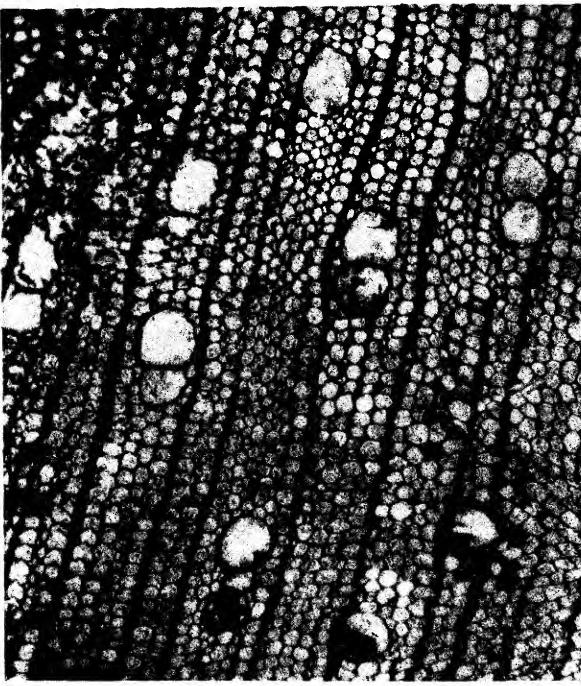
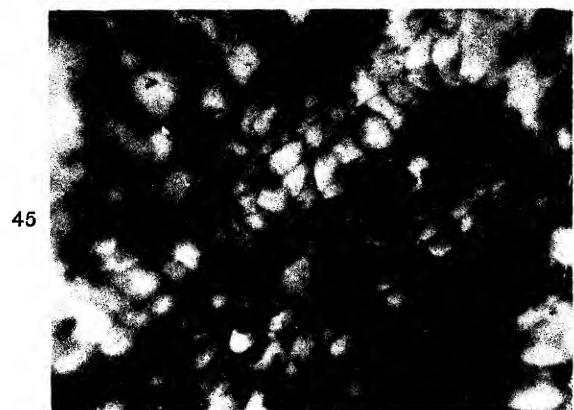
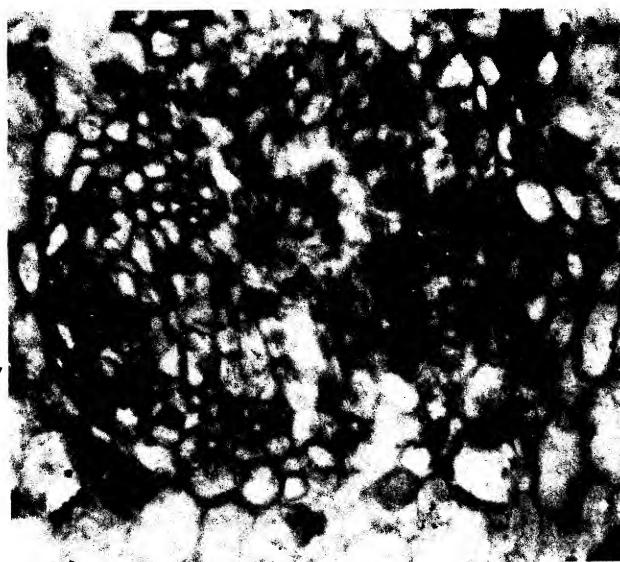
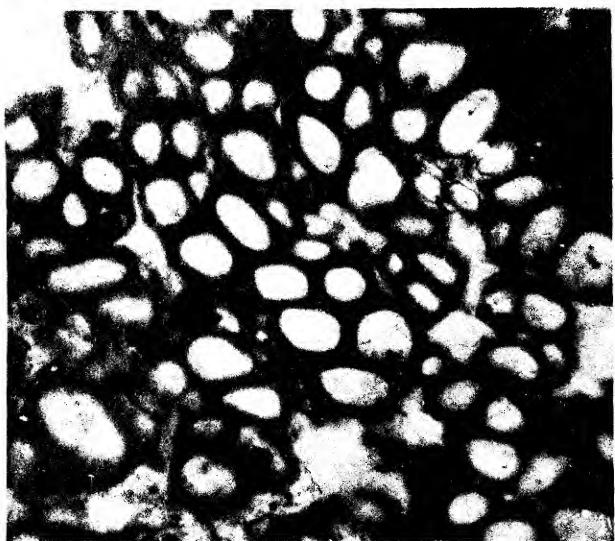
39

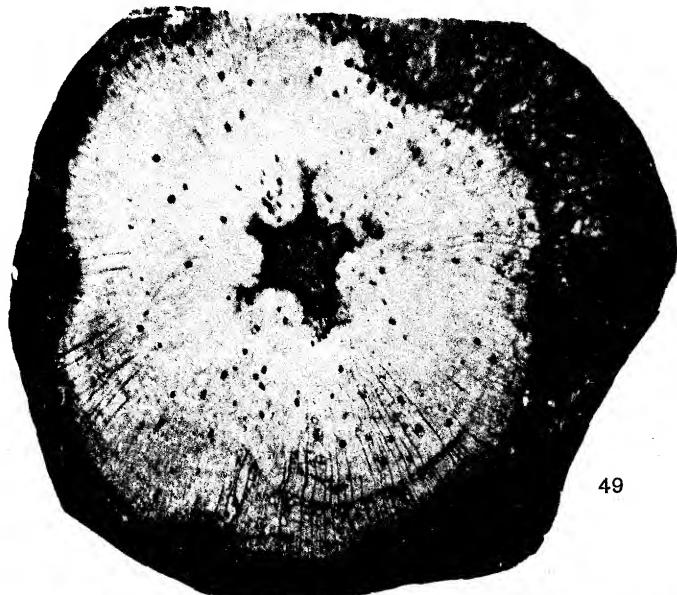


40

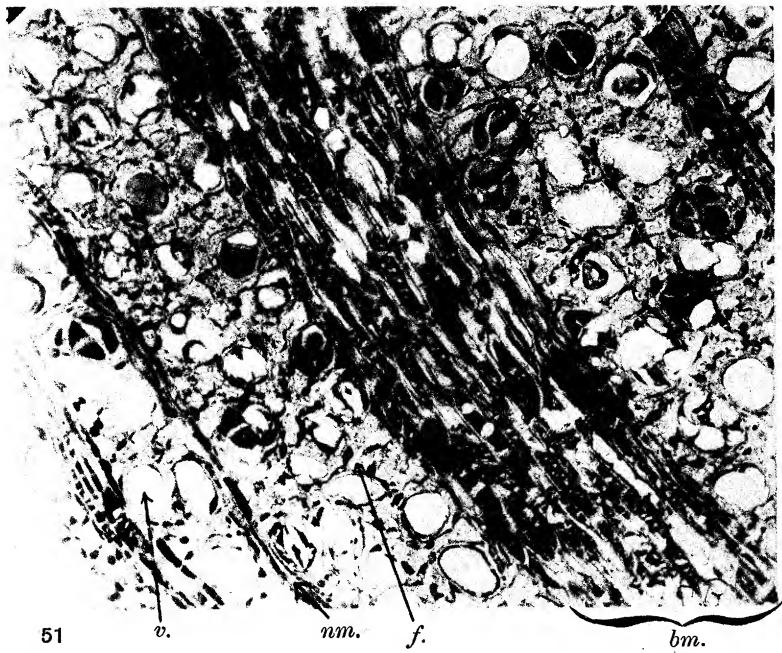
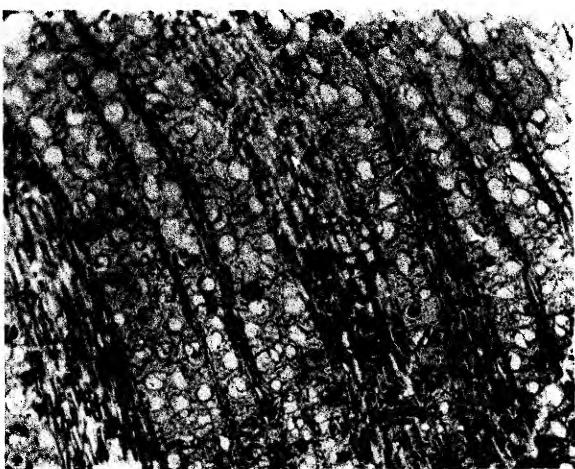


41



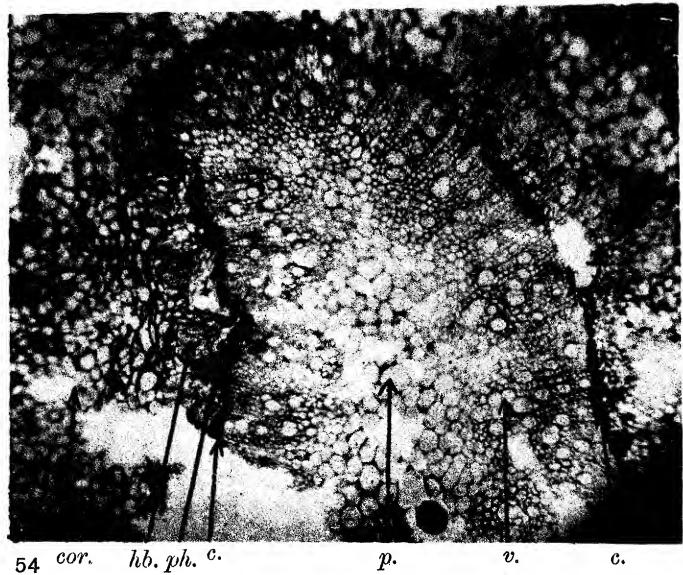


50



51

52



54 cor. hb. ph. c.

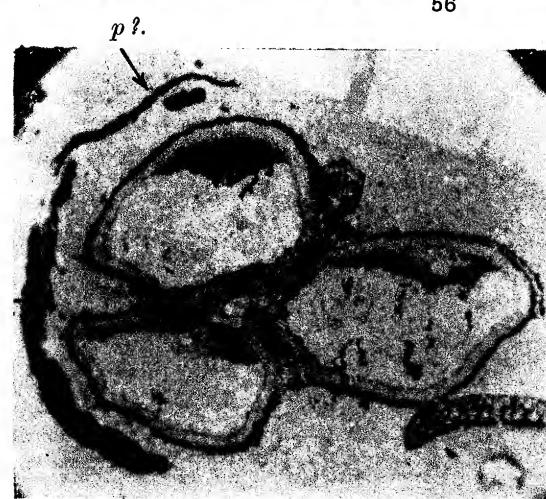
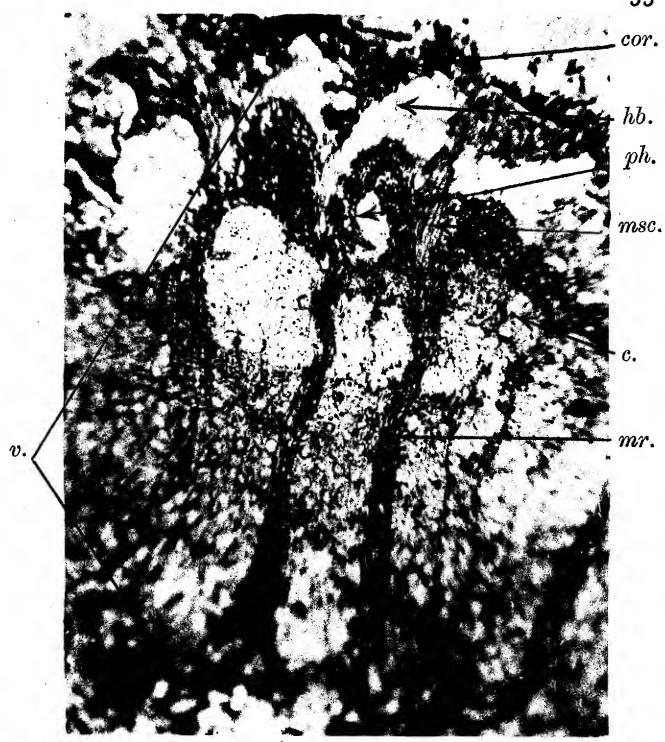
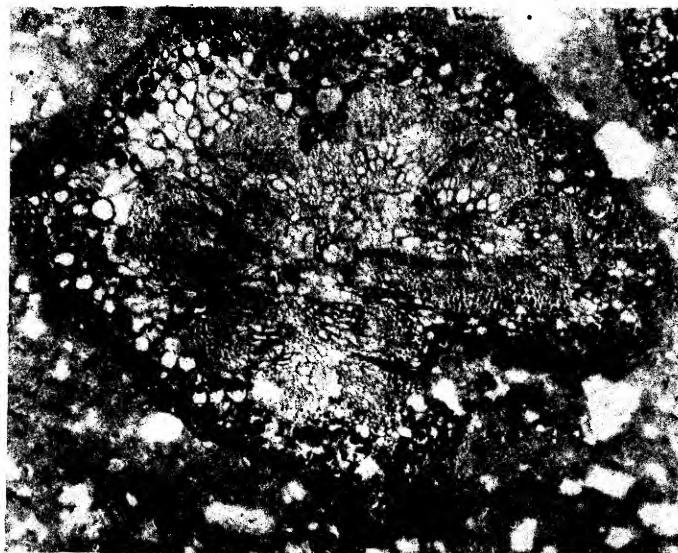
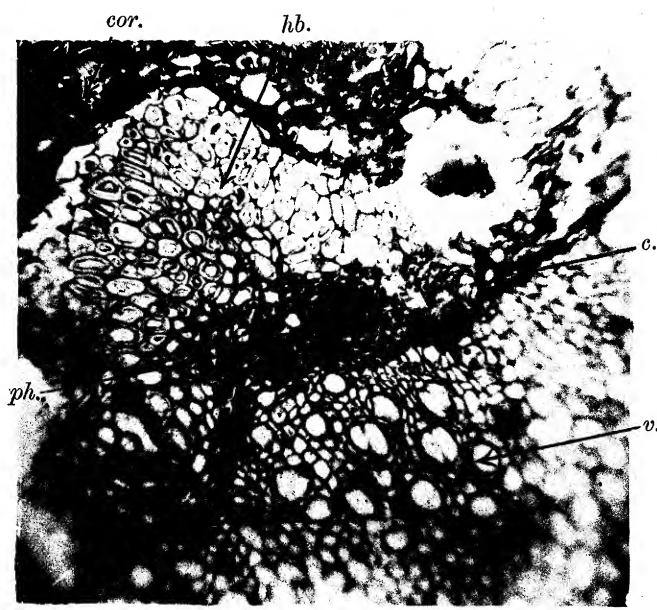
p.

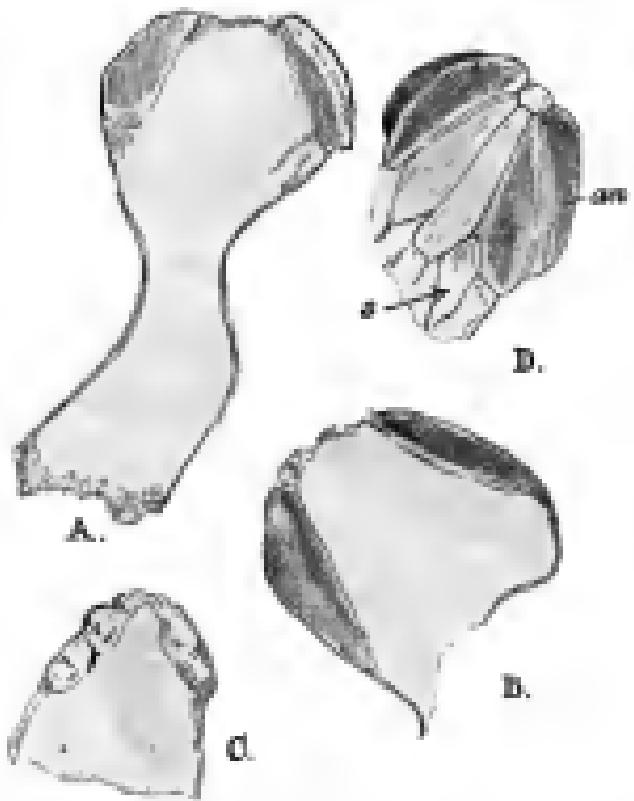
v.

c.

53

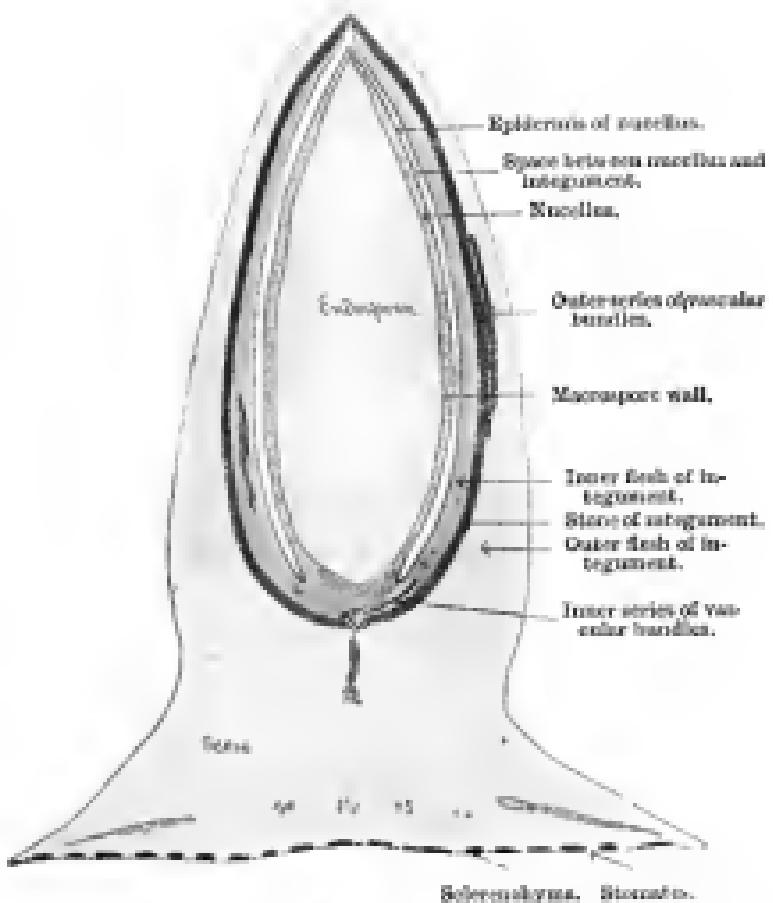






TEXT-FIG. 3.—Sporangia of *Schizosphaeris massonica*, STROBL and FUJII.

A, longitudinal drawing of a complete sporangium, showing the base of attachment and the apical cap; B and C, details of the annulus in longitudinal and oblique sections; D, part of a surface view of one of the sporangia, showing the thick-walled annulus cells, an, and the form of the sporangial wall, s.



TEXT-FIG. 13.—Diagram of the Seed of *Xestrobus*. This is partially restored. The micropyle is not given at the apex, as there is not evidence enough to determine its appearance. $\times 11$.



PLATE 1.

Figs. 1-6.—*Petrospharia japonica*, STOPES and FUJII.

Fig. 1.—Cells of the cortex of *Saururopsis* infested with hyphae of the fungus. $\times 500$.

Fig. 2.—End of a hypha of *Petrospharia*, cut off by a transverse septum and much swollen and thickened. $\times 750$.

Fig. 3.—Hyphae of the same, irregularly thickening and swelling. $\times 750$.

Figs. 4 and 5.—Nests of thickened "cells" in the periderm of the host, showing the common fern in which they occur. $\times 750$.

Fig. 6.—Section through one of such masses as are shown in figs. 4 and 5. This shows the very thick walled nature of the plectenchyma. *h.*, hyphae, apparently connected with the mass, possibly germinating from it. $\times 800$.

Fig. 7.—*Fasciostelopteris Tansleii*, STOPES and FUJII.

Transverse section of part of a stipe of the main axis, showing:—

g. Ground tissue, thick walled (cf. Phot. 2, Plate 2, *g.*).

en. Endodermis.

p. Pericycle.

ph.s. Phloem sheath.

t.ph. Thickened cells, presumably phloem.

ph.sv. Cells, presumably sieve tubes.

w.s. Wood sheath.

x. Xylem. $\times 180$.

Figs. 8 and 9.—Seed of *Yezostrobus Oliveri*, STOPES and FUJII.

Fig. 8.—Longitudinal section of a part of the seed (cf. Phot. 11, Plate 3).

o.f. Outer flesh of integument, with *c.* secretory or resinous cells (?).

st. Stone layer of the integument.

i.f. Inner flesh of the integument.

i.e. Epidermis bounding the inner flesh of the integument.

sp. Space between the integument and the nucellus.

en. Epidermis bounding the nucellus.

n. Cells of the nucellus.

Fig. 9.—A few of the cells from the stone of the seed, showing the irregular mingling of transversely and longitudinally running elements.

s. Ordinary stone cells, showing the pit canals.

b. Cells with walls rather less thickened and filled with a blackened mass.

Fig. 10.—Medullary rays of *Cedrocydon Matsumurae*.

Part of a radial section of a medullary ray, crossing poorly preserved tracheids, but showing structures highly suggestive of nuclei in the ray cells.

Fig. 11.—*Cryptomeriopsis antiqua*, STOPES and FUJII.

External appearance of leaf at L. Broken across in the surface s. are other leaves of the plant, l. $\times 2$.

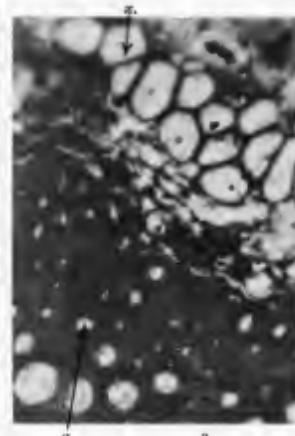
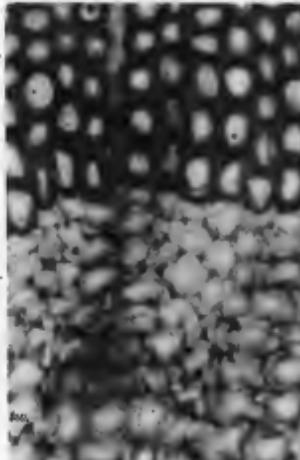
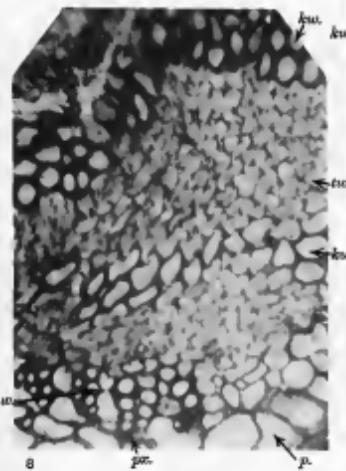
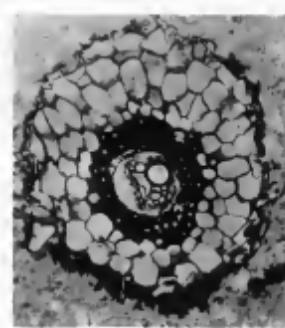
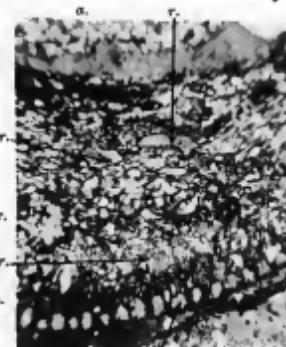
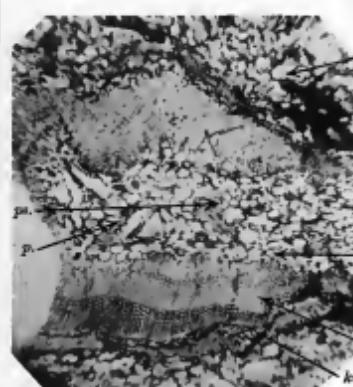
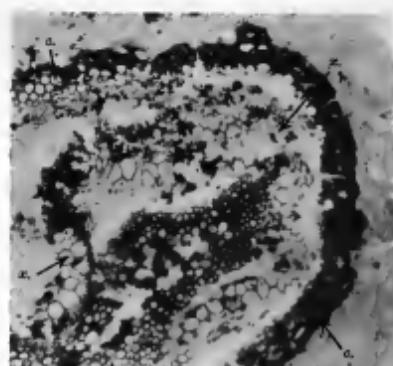
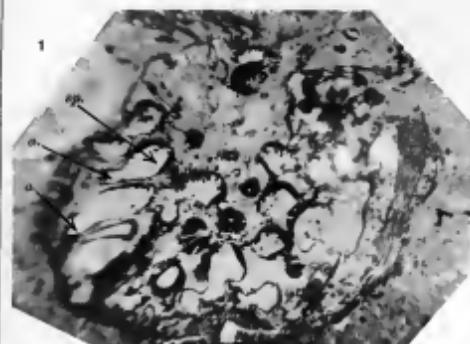


PLATE 2.

Phot. 1.—*Schizopteris mesozoica*, STOPES and FUJII.

Photo of the sorus, with numerous sporangia attached to, and in the neighbourhood of, the sporophyll.

sp. Sporangium, attached at *a*.

(Compare text-fig. 3 for details, and text-figs. 1 and 2 for diagrams of the sorus and sporangia.) $\times 45$.

Phot. 2 and 3.—*Fasciostelopteris Tanscii*, STOPES and FUJII.

Phot. 2.—Portion of the main axis, showing the very curved band-like strands of wood.

x. Xylem.

c. Cortical tissues.

g. Central ground tissue.

(Compare text-diagram 4.)

Phot. 3.—Part of the ground tissue and vascular strand of the main axis.

g. Ground tissue in the neighbourhood of the stele, showing its extremely thick walls.

x. Xylem of the stele.

(Compare Plate 1, fig. 7, for details of the stele.)

Phot. 4.—Transverse section of a fern rootlet.

Showing the diarch stele, thickened inner cortex, and large-celled outer cortex. $\times 55$.

Phot. 5–8.—*Yezonia vulgaris*, STOPES and FUJII.

Phot. 5.—Transverse section of the main axis, showing secondary wood.

p. Pith.

p.s. Nests of sclerenchyma in the pith.

px. Protoxylems.

tw. "Thin-walled" wood.

kw. "Thick-walled" wood.

r. Secretory canals.

c. Cortex.

Phot. 6.—Part of the wood of the main axis.

p. Pith cells.

px. Protoxylems.

tw. Metaxylem.

kw. "Thick-walled" wood.

tw. "Thin-walled" wood.

(Compare Phot. 7.)

Phot. 7.—Detail of the wood, showing the "thick-walled," *kw.*, on the same radii as the "thin-walled," *tw.*

Phot. 8.—Leaf base attached to the main axis, *a*.

r. Large irregular secretory passages.

tr. Zone of transfusion tissue.

sc. Strands of hypodermic sclerenchyma, alternating with soft tissue into which the stomata open.

(Compare text-diagram 11.)

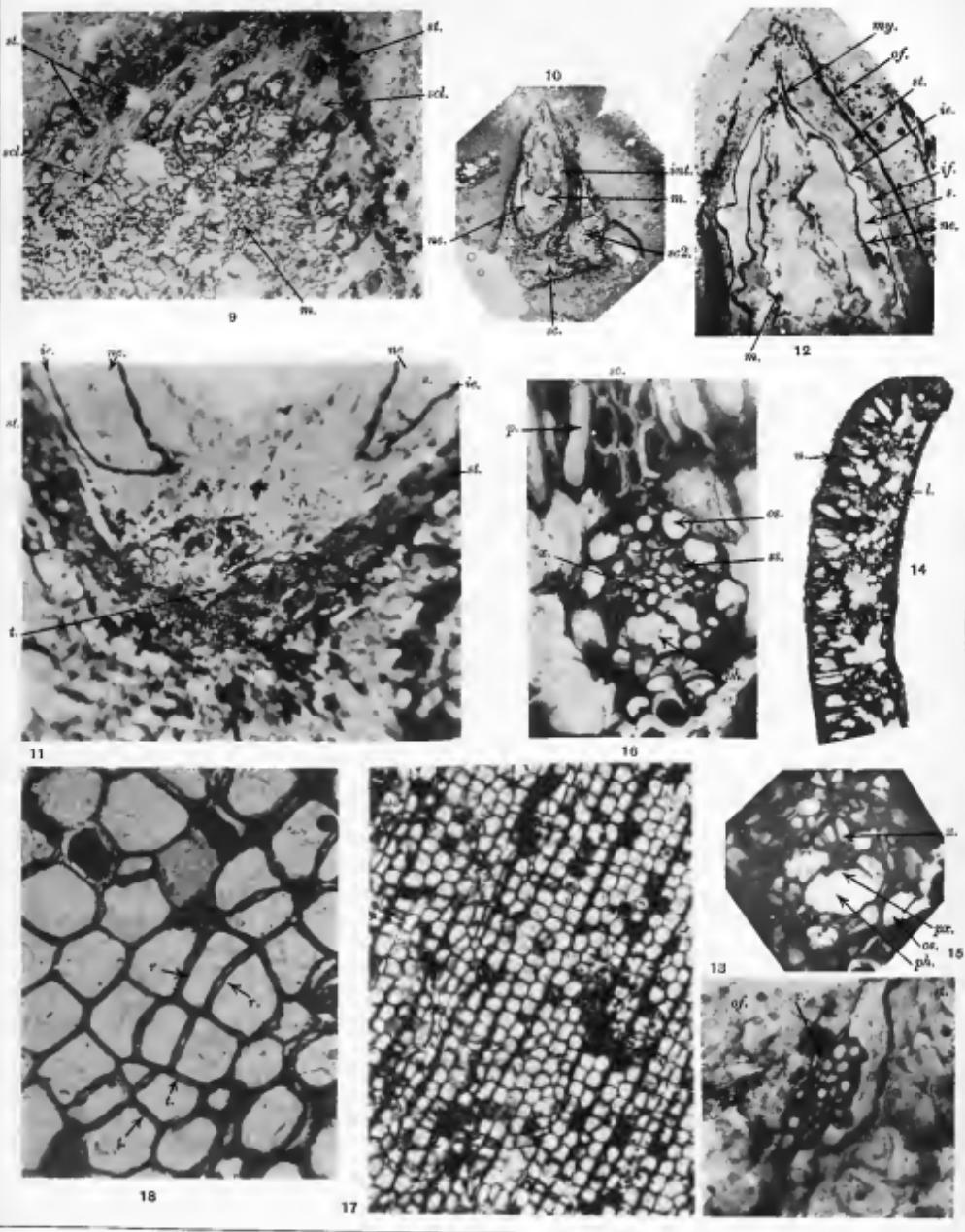


PLATE 3.

Phot. 9.—*Yezonia vulgaris*, STOPES and FUJII.

A tangential section through a leaf surface, showing the rows of stomates, st., alternating with the strands of hypodermic sclerenchyma, scl. m., general soft ground tissue of the leaf.

Photos. 10–13.—*Yezostrobus Oliveri*, STOPES and FUJII.

Phot. 10.—Longitudinal section of the seed attached to the scale.

- x. Direction of axis of the seed.
- sc. Scale. int. Integument.
- ne. Nucellar epidermis.
- m. Macrospore.
- sc.² Scales of other seeds.

(Cf. text-fig. 13.) × 3·6

Phot. 11.—Part of the base of seed in Phot. 10 enlarged.

- ne. Nucellar epidermis.
- s. Space between nucellus and integument.
- ie. Epidermis of inner integument.
- st. Stone.
- t. Tracheids at the base of the seed.

Phot. 12.—Apex of seed in Phot. 10 enlarged.

- of. Crushed streak, remnant of outer flesh.
- st. Stone.
- if. Inner flesh.
- ie. Epidermis of inner flesh.
- s. Space between integument and nucellus.
- ne. Epidermis of nucellus.
- m. Macrospore membrane.
- my. Base of micropyle.

Phot. 13.—Vascular strand of seed in transverse section, v.; it lies just outside the stone cells, st. The position of the outer flesh (which has largely decayed) is marked at of.

Photos. 14–16.—*Nipponophyllum cordaitiforme*, STOPES and FUJII.

Phot. 14.—Portion of leaf in transverse section, to show the numerous parallel veins.

- u. Upper surface of leaf.
- l. Lower surface of leaf.

(Compare diagrams in text-figs. 5–7.)

Phot. 15.—A single vascular bundle from the leaf, showing:

- px. Protoxylem.
- x. Xylem.
- os. Outer sheath cells of bundle sheath.
- ph. Space where phloem lay.

Phot. 16.—Bundle and some of the surrounding tissue of the leaf.

- sc. Sclerenchyma above the bundle.
- p. Palisade cells.
- os. Outer bundle sheath.
- ss. Inner, thick-walled bundle sheath.
- x. Xylem.
- ph. Position of phloem.

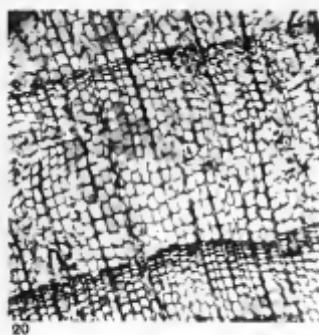
(Compare text-fig. 7.)

Photos. 17 and 18.—*Araucarioxylon Takoense*, sp. nov.

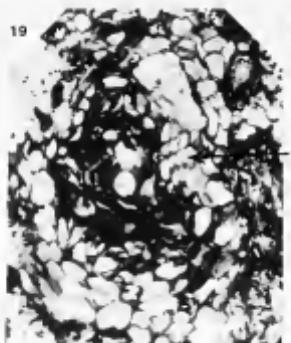
Phot. 17.—Transverse section of the wood.

Phot. 18.—Transverse section of part of the wood in Phot. 17, on a larger scale, to show the rows of pittings in the walls.

- r. Pits in radial walls.
- t. Pits in tangential walls.



20



19



21



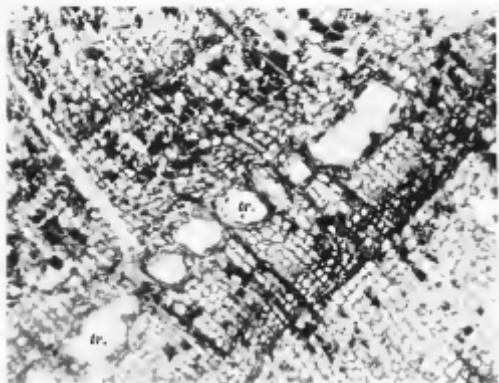
22



23



25



24



26

PLATE 4.

Phot. 19.—*Yezonia vulgaris*, STOPIES and FUJII.

A single secretory passage in an old stem, within which a cork-like layer (*l.*) is forming.

Phot. 20–23.—*Cedroxyxon Matsumurae*, sp. nov.

Phot. 20.—Transverse section of the secondary wood, showing well-marked annual rings.

Phot. 21.—Summer and autumn wood, enlarged to show the details of the tracheids.

Phot. 22.—Longitudinal section of some tracheids, to show pitting on the walls, in single and double rows.

Phot. 23.—Longitudinal section, to show the medullary rays; single cells broad and of varying heights.

Phot. 24–26.—*C. Yendoi*, sp. nov.

Phot. 24.—Transverse section of the secondary wood, showing a row of traumatic resin canals, *tr.* (vertically running canals).

Phot. 25.—Tangential section, showing the medullary rays, *m.*, and in two of them the horizontally running traumatic resin canals, cut across, *tr.*

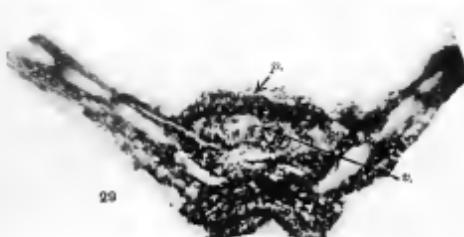
Phot. 26.—Tangential section of the wood, showing the small medullary cells; a single row of cells broad and two or three high.



27



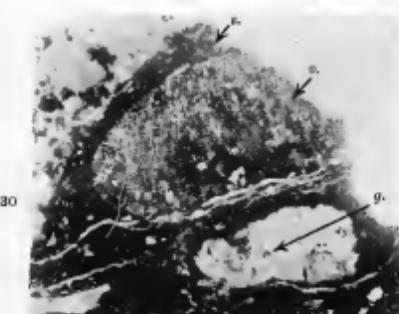
28



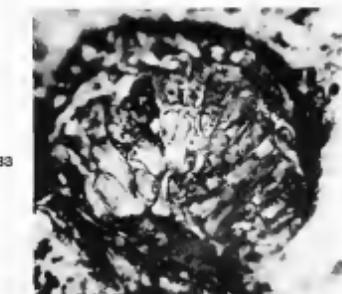
29



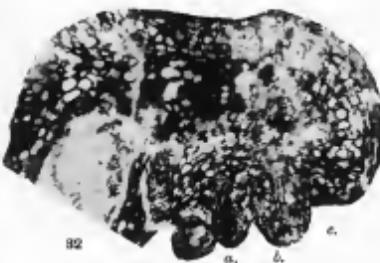
31



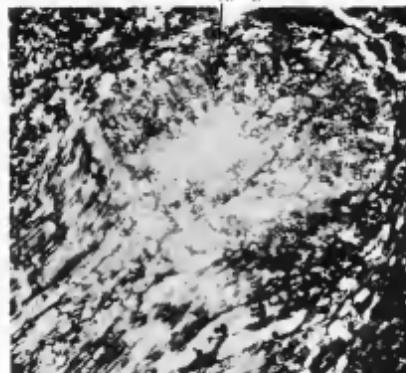
30



33



32



34

ax.

PLATE 5.

Phot. 27.—Natural size view of the cone which projected through the nodule surface before cutting.

Phot. 28.—Part of transverse section through a scale.

- v. Vascular strands.
- t. Transfusion tracheids between them.
- h. Hypodermic row of sclerised cells.
- g. Secretory canals.

Phot. 29.—Single scale in transverse section. (The lateral expansions have been cut off in the photo. Compare text-fig. 15.)

- v. Row of vascular bundles.
- p. Pad of tissue on which presumably the seeds were borne.

Phot. 30.—Part of scale, to show the large undivided vascular bundle, v.

From this a small strand, s., is coming off.

- g. Large secretory canal below the bundle (cf. text-fig. 15).

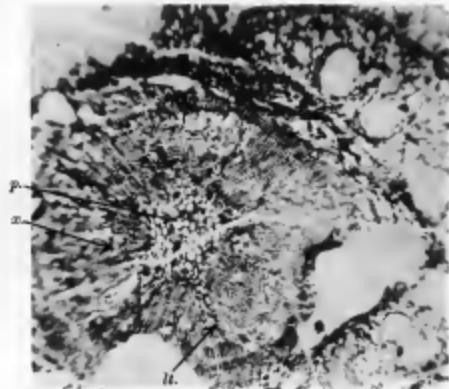
Phot. 31.—High power view of the transfusion tracheids.

Phot. 32.—A scale from the apex of the cone, with three protuberances, *α*, *β*, and *γ*, which are presumably ovules.

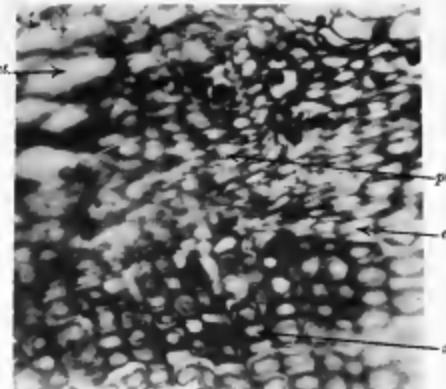
(Cf. Phot. 33.)

Phot. 33.—Protuberance *α* of Phot. 32 enlarged, showing the regular, closely packed tissue, unlike that of the ground tissue of the scale.

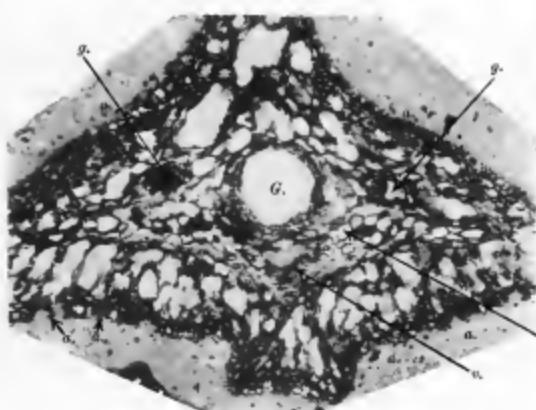
Phot. 34.—The exit of a scale strand, *s.c.t.*, from the main axis tissues, *ax.*, showing its large size and semicircular form.



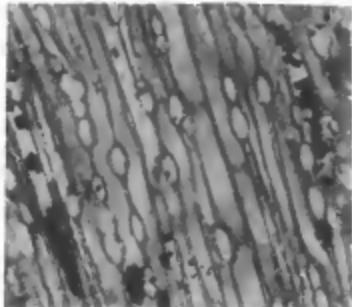
35



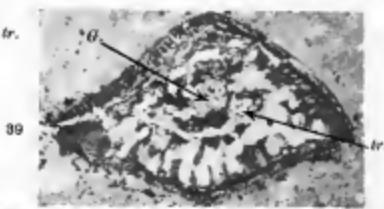
37



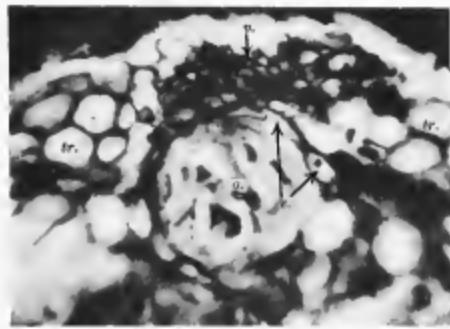
38



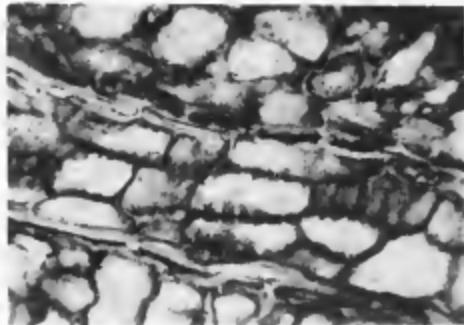
36



39



40



41

PLATE 6.

Phot. 35.—Section through main axis, surrounded by leaf bases.

- p.* Pith.
- x.* Secondary wood.
- lt.* Leaf trace passing through the secondary wood.

Phot. 36.—Tangential longitudinal section of the wood of the main axis, to show the medullary rays, one cell broad and nearly all one cell in height.

Phot. 37.—Transverse section of part of the secondary wood, *x.*, with outside it the cambium zone, *c.*, and the phloem, *ph.* *ct.*, cortical cells.

Phot. 38.—Transverse section of the base of a leaf.

- G.* Central secretory canal.
- g.* Lateral secretory canals.
- v.* Vascular strand. *tr.* Transmutation tracheids.
- a, a.* Position of stomates.

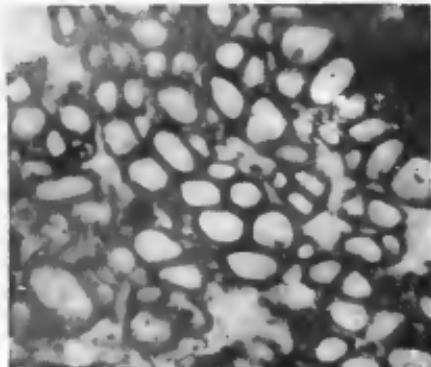
Phot. 39.—Transverse section toward the tip of the leaf.

- G.* Single central secretory canal, the lateral ones have died out by this level.
- tr.* Transmutation tracheids.

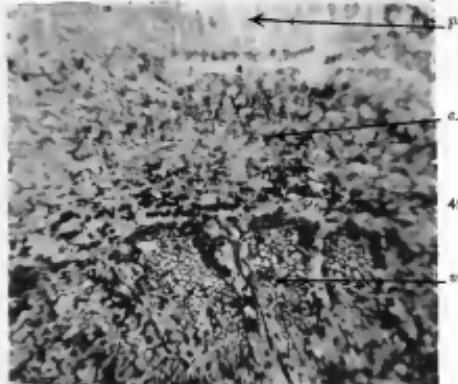
Phot. 40.—Enlargement of the central secretory canal, *G.*, such as is seen in Phot. 38, showing two or three cells, like an epithelial lining, *e.*

- v.* Vascular bundle.
- tr.* Transmutation tracheids.

Phot. 41.—Longitudinal view of strand of transmutation tracheids, showing the markings on their walls.



43

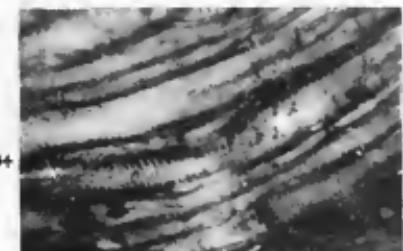


p.

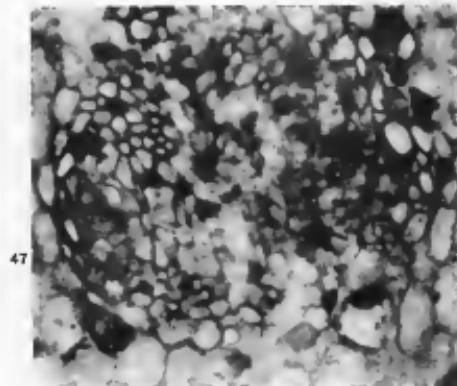
c.

v.

42



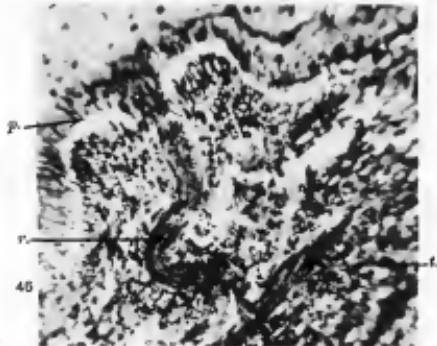
44



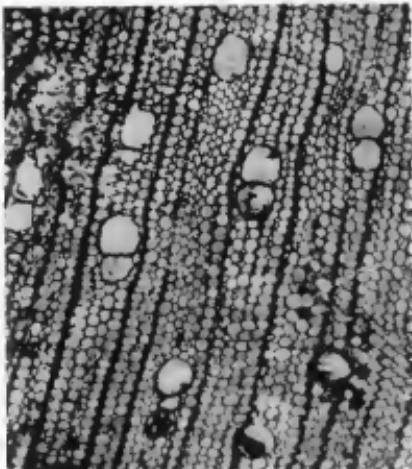
47



45



46



48

PLATE 7.

Photos. 42-47.—*Saurauia opsis nipponensis*, STOPES and FUJII.

Phot. 42.—Transverse section of part of the axis.

v. Vascular bundles.

c. Cortical regions.

p. Periderm.

Phot. 43.—Part of the wood from such a bundle as that shown in Phot. 42, enlarged, showing the uniform size of the wood elements.

Phot. 44.—Longitudinal section of the wood elements, showing their scalariform thickenings.

Phot. 45.—Transverse section of region outside the wood, which looks very suggestive of phloem tissue.

Phot. 46.—Section of outer part of the cortex, with the strand of an outgoing rootlet, showing the curved form of the strand coming from a tangentially running bundle in the cortex.

p. Periderm of cortex.

t. Tangentially running strand.

r. Strand going out to rootlet.

Phot. 47.—Transverse section of a rootlet running in the cortex.

Phot. 48.—*Juglroxylon Hamaoanum*, STOPES and FUJII.

Transverse section of the wood, showing vessels, regularly arranged fibres, and medullary rays.

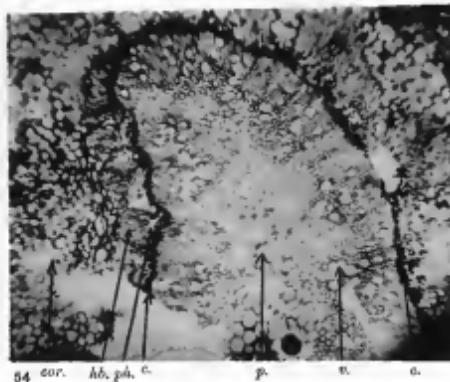
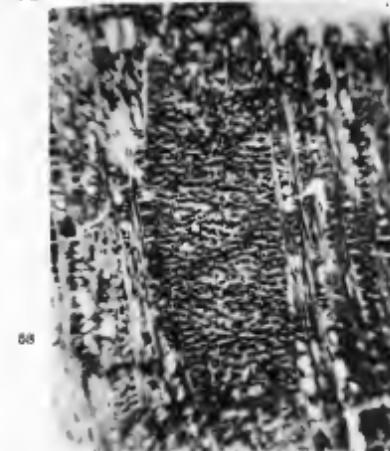
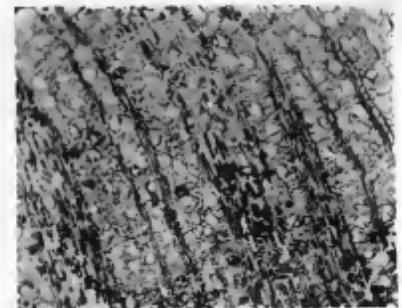
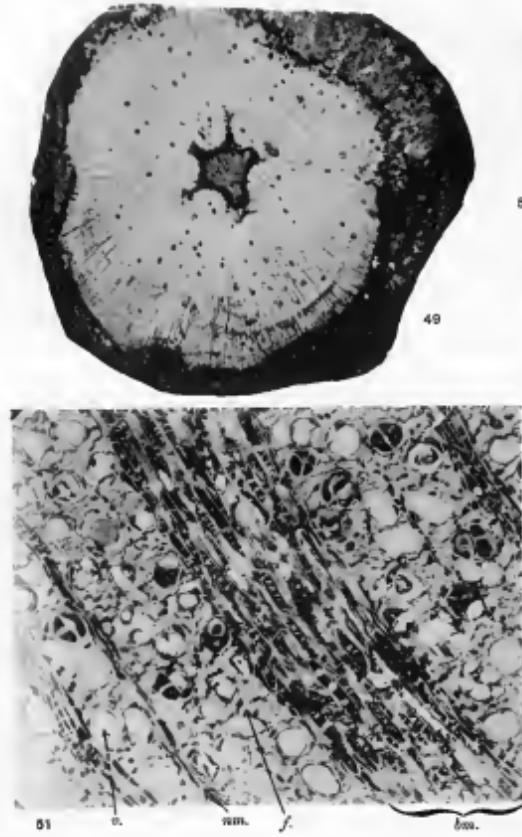


PLATE 8.

Phot. 49.—*Populocaulis yezocensis*, STOPES and FUJII.

Phot. 49.—Transverse section of the stem, showing the five-rayed pith, the secondary wood with medullary rays, and a portion of the cortex.

Phot. 50–53.—*Jugloxyylon Hamaoanum*, STOPES and FUJII.

Phot. 50.—Transverse section of secondary wood, showing the broad medullary rays alternating with the narrow ones, and the numerous large vessels.

Phot. 51.—Part of wood of Phot. 50 enlarged, transverse section.

bm. Broad medullary ray; note the oblique tangential walls of the elements composing it.

nm. Narrow medullary rays.

v. Vessels.

f. Wood fibres, thick-walled, in which pittings can be seen (*cf.* Phot. 52).

Phot. 52.—Wood fibres enlarged to show the pit canals, *p.*

l. Lumen of fibres.

v. Vessels, only partly within the field of the photograph.

Phot. 53.—Tangential section of a broad medullary ray.

Phot. 54.—*Sabiocaulis Sakuraii*, STOPES and FUJII.

Part of the stem in transverse section.

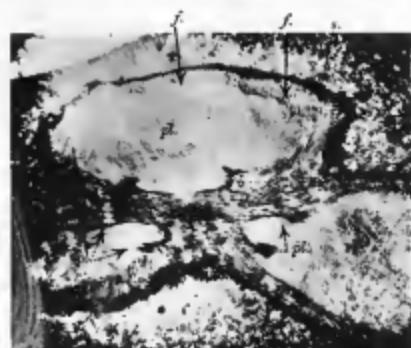
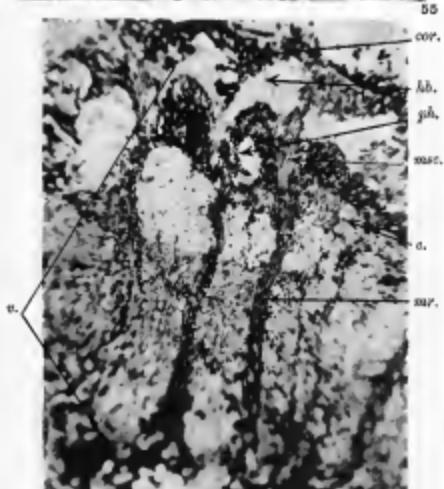
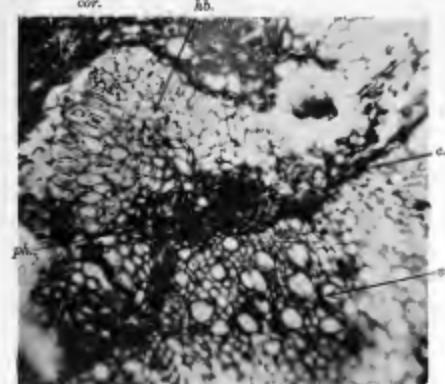
p. Pith.

v. Vascular bundles.

c. Cambium zone.

ph. Phloem, capped by hard bast fibres, *hb.*

cor. Cortex.



60

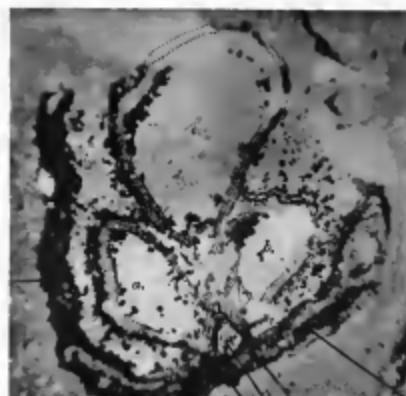
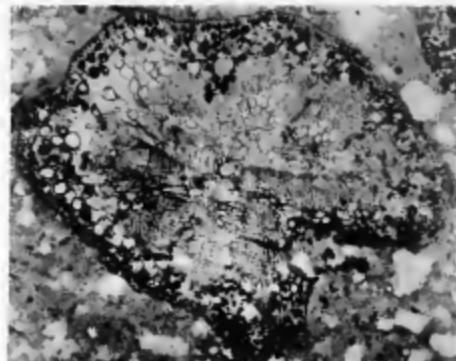


PLATE 9.

Photos. 55-57.—*Sabiocaulis Sakurasi*, STORES and FUJII.

Phot. 55.—Part of a bundle from Phot. 54, Plate 8, enlarged.

- v. Wood vessels.
- c. Cambium zone.
- ph. Phloem.
- hb. Hard bast fibres, forming a solid cap behind the bundle.
- cor. Cortex.

Phot. 56.—Transverse section of a complete minute twiglet, showing a ring of bundles arranged in a slightly horseshoe-shaped fashion.

Phot. 57.—Part of the bundles of an older stem in transverse section.

- v. Vascular bundle, radially extended by secondary growth.
- mr. Medullary rays, continuous between all the primary bundles. m.s.c., sclerised outer portions of the rays.
- c. Region of cambium.
- ph. Phloem.
- hb. Hard bast cap.
- cor. Cortex.

Photos. 58-60.—*Cretovarium japonicum*, STORES and FUJII.

Phot. 58.—Transverse section of the trilocular ovary, with perianth, p., partly round it.

Phot. 59.—Slightly oblique section of the trilocular ovary, with perianth, p.

The loculi, a and b, are attached to the perianth at points t, t. s., small space between carpels and perianth.

Phot. 60.—Transverse section of part of three carpels from another ovary of *Cretovarium*.

- f. Inner fibrous layer of ovary wall.
- s. Outer layer, probably soft tissue, represented by crushed blackened mass.
- pl. Placentae, two in each carpel, indicating that the ovules were in two rows.

× 40.